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Funding

Summary

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
61101E	CCS-02	INFORMATION SCIENCES	18.372	36.386	24.593	26.700	18.700	20.700	20.700	20.700
	ES-01	ELECTRONIC SCIENCES	21.429	16.498	18.243	17.645	18.506	21.365	21.365	21.365
	MS-01	MATERIALS SCIENCES	26.232	37.531	22.427	25.053	27.053	19.053	19.053	19.053
	BLS-01	BIO/MICRO/INFO SYSTEMS	0.000	0.000	40.000	40.000	50.000	55.000	60.000	65.000
	61101E	**DEFENSE RESEARCH SCIENCES**	**66.033**	**90.415**	**105.263**	**109.398**	**114.259**	**116.118**	**121.118**	**126.118**
62110E	**NGI-01**	**NEXT GENERATION INTERNET**	**35.425**	**15.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	ST-01	JASONS	1.190	1.200	1.200	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	71.074	88.024	68.403	44.536	65.393	68.034	68.034	68.034
	ST-19	HIGH PERFORMANCE & GLOBAL SCALE SYS	159.595	152.795	116.351	142.138	141.355	155.043	155.043	165.043
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.630	17.965	18.500	19.300	19.300	19.300	0.000	0.000
	ST-24	INFORMATION SURVIVABILITY	63.839	92.802	88.738	85.800	64.500	70.000	70.000	70.000
	ST-28	ASYMMETRIC THREAT	0.000	23.806	50.087	45.700	45.500	45.000	50.000	55.000
	62301E	**COMPUTING SYS & COMM TECHNOLOGY**	**312.328**	**376.592**	**343.279**	**338.674**	**337.248**	**358.577**	**344.277**	**359.277**
62302E	AE-01	DEEPLY NETWORKED SYSTEMS	5.405	13.513	20.656	25.000	30.000	32.000	42.000	42.000
	AE-02	SOFTWARE FOR AUTONOMOUS SYSTEMS	16.873	17.171	41.055	32.000	22.000	18.000	18.000	18.000
	AE-03	SOFTWARE FOR EMBEDDED SYSTEMS	7.722	23.821	32.700	32.000	40.000	40.000	40.000	40.000
	AE-04	GIGABYTE APPLICATIONS	0.000	14.777	19.785	18.000	13.000	10.000	10.000	10.000
	62302E	**EXTENSIBLE INFORMATION SYSTEMS**	**30.000**	**69.282**	**114.196**	**107.000**	**105.000**	**100.000**	**110.000**	**110.000**
62383E	**BW-01**	**BIOLOGICAL WARFARE DEFENSE**	**125.466**	**162.064**	**140.180**	**149.000**	**169.000**	**173.000**	**173.000**	**173.000**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
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PE	PROJ	TITLE	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	14.374	0.000	15.000	15.000	20.000	26.200	36.200	36.200
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	26.034	21.972	19.425	32.348	29.162	35.144	35.144	35.144
	TT-06	ADVANCED TACTICAL TECHNOLOGY	33.221	32.232	42.322	42.073	44.230	41.371	41.371	41.371
	TT-07	AERONAUTICS TECHNOLOGY	40.302	29.131	26.475	32.593	42.450	44.291	47.291	47.291
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	14.993	27.791	23.564	23.800	23.800	24.300	24.300	24.300
	TT-11	JOINT LOGISTICS ACTDS	9.390	9.925	9.893	0.000	0.000	0.000	0.000	0.000
	62702E	**TACTICAL TECHNOLOGY**	**138.314**	**121.051**	**136.679**	**145.814**	**159.642**	**171.306**	**184.306**	**184.306**
62708E	**IC-03**	**INTEGRATED COMMAND & CONTROL TECH**	**37.218**	**31.761**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	126.014	130.759	150.031	152.472	152.554	153.395	155.395	155.395
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	85.238	96.783	66.229	54.858	60.215	70.556	75.556	75.556
	MPT-06	CRYOGENIC ELECTRONICS	27.203	22.270	14.994	7.945	7.802	9.643	9.643	9.643
	MPT-08	BEYOND SILICON	0.000	0.000	40.000	50.000	50.000	55.000	60.000	65.000
	62712E	**MATERIALS & ELECTRONICS TECHNOLOGY**	**238.455**	**249.812**	**271.254**	**265.275**	**270.571**	**288.594**	**300.594**	**305.594**
63285E	**ASP-01**	**ADVANCED AEROSPACE SYSTEMS**	**17.187**	**26.821**	**42.700**	**55.000**	**65.986**	**73.986**	**63.986**	**63.986**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
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PE	PROJ	TITLE	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
63739E	MT-03	UNCOOLED INTEGRATED SENSORS	10.599	11.916	6.930	0.000	0.000	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	51.066	43.684	45.772	48.067	48.029	46.829	46.829	46.829
	MT-05	TACTICAL INFORMATION SYSTEMS	23.368	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	5.364	4.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPL	15.484	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	45.679	45.012	25.013	25.000	25.000	25.000	0.000	0.000
	MT-12	MEMS & INTEGRATED MICROSYSTEMS TECH	72.916	37.712	37.590	24.000	24.025	10.825	10.825	10.825
	MT-15	MIXED TECHNOLOGY INTEGRATION	21.479	49.476	62.959	71.800	77.300	72.300	77.300	77.300
	63739E	**ADVANCED ELECTRONICS TECHNOLOGY**	**245.955**	**191.800**	**178.264**	**168.867**	**174.354**	**154.954**	**134.954**	**134.954**
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYS	97.657	79.209	63.068	67,234	70.234	73.234	67.234	67.234
	CCC-02	INFORMATION INTEGRATION SYSTEMS	79.189	49.654	44.120	32.246	29.512	34.837	35.837	35.837
	63760E	**COMMAND, CONT'L & COMMUNICATION SYS**	**176.846**	**128.863**	**107.188**	**99.480**	**99.746**	**108.071**	**103.071**	**103.071**
63762E	SGT-01	GUIDANCE TECHNOLOGY	19.301	22.173	22.199	23.964	43.514	46.564	46.564	46.564
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGIES	41.713	61.545	78.838	88.232	90.550	100.000	109.300	109.300
	SGT-03	AIR DEFENSE INITIATIVE	36.340	24.301	14.667	15.000	22.750	39.200	48.200	53.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	76.591	74.206	72.720	73.286	92.582	92.832	92.832	92.832
	63762E	**SENSOR & GUIDANCE TECHNOLOGY**	**173.945**	**182.225**	**188.424**	**200.482**	**249.396**	**278.596**	**296.896**	**301.896**
63763E	**MRN-02**	**MARINE TECHNOLOGY**	**21.107**	**30.304**	**30.257**	**42.896**	**47.696**	**57.496**	**80.196**	**92.596**

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PE	PROJ	TITLE	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY	51.522	38.129	19.992	16.500	27.500	32.000	32.000	32.000
	LNW-02	SMALL UNIT OPERATIONS	42.086	35.120	37.675	37.600	33.500	35.000	45.000	45.000
	LNW-03	FUTURE COMBAT SYSTEMS	0.000	61.000	90.000	122.000	62.000	15.000	15.000	15.000
	63764E	**LAND WARFARE TECHNOLOGY**	**93.608**	**134.249**	**147.667**	**176.100**	**123.000**	**82.000**	**92.000**	**92.000**
63765E	**CLP-01**	**CLASSIFIED**	**56.606**	**101.387**	**110.795**	**99.100**	**55.000**	**35.000**	**35.000**	**35.000**
65114E	**BL-01**	**BLACKLITE**	**4.961**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**4.960**	**4.960**
65502E	**SB-01**	**SMALL BUSINESS**	**42.812**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
65898E	**MH-01**	**MANAGEMENT HEADQUARTERS (R&D)**	**32.132**	**34.679**	**38.954**	**40.314**	**42.402**	**42.502**	**42.542**	**42.542**
	AGENCY TOTAL		**1,848.398**	**1,951.305**	**1,960.100**	**2,002.400**	**2,018.300**	**2,045.200**	**2,086.900**	**2,129.300**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in millions)

PE	PROJ	TITLE	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007
	BA-01	TOTAL	66.033	90.415	105.263	109.398	114.259	116.118	121.118	126.118
	BA-02	TOTAL	917.206	1,025.562	1,005.588	1,005.763	1,041.461	1,091.477	1,112.177	1,132.177
	BA-03	TOTAL	785.254	795.649	805.295	841.925	815.178	790.103	806.103	823.503
	BA-06	TOTAL	79.905	39.679	43.954	45.314	47.402	47.502	47.502	47.502
	AGENCY TOTAL		1,848.398	1,951.305	1,960.100	2,002.400	2,018.300	2,045.200	2,086.900	2,129.300

R-2

Exhibits

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	66.033	90.415	105.263	109.398	114.259	116.118	121.118	126.118	Continuing	Continuing
Information Sciences CCS-02	18.372	36.386	24.593	26.700	18.700	20.700	20.700	20.700	Continuing	Continuing
Electronic Sciences ES-01	21.429	16.498	18.243	17.645	18.506	21.365	21.365	21.365	Continuing	Continuing
Materials Sciences MS-01	26.232	37.531	22.427	25.053	27.053	19.053	19.053	19.053	Continuing	Continuing
Bio/Info/Micro Systems BLS-01	0.000	0.000	40.000	40.000	50.000	55.000	60.000	65.000	Continuing	Continuing

(U) **Mission Description:**

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.

(U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as computational models, new mechanisms for performing computation and communication, innovative approaches to the composition of software, and novel human computer interface technologies. This project will also explore scientific study and experimentation emphasizing biological software, computations based on biological materials, physical interfaces between electronics and biology, and interactive biology. The Bio/Info/Micro systems efforts previously budgeted in this project transfer to Project BLS-01 in FY 2002.

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; spin-dependent materials and devices; advanced thermoelectric materials for cooling and power generation; new materials discovery; and novel propulsion concepts.

(U) The Bio/Info/Micro Systems project will develop methods at the interface of information technology, biology and micro-systems to exploit computational properties of biological substrate at the genetic level, protein-protein interaction level, cellular level, and organ level. Areas of investigation include biosequencing, biological computation, nanofluidic biomolecular networks, and biointerfaces.

(U) **Program Change Summary:** (*In Millions*)	**FY2000**	**FY 2001**	**FY 2002**	**FY 2003**
Previous President's Budget	67.608	90.415	94.263	94.398
Current Budget	66.033	90.415	105.263	109.398

(U) **Change Summary Explanation:**

FY 2000	Decrease reflects SBIR reprogramming and minor program realignments.
FY 2002 - 03	Increases reflect additional funding for the Bio/Info/Micro Systems project (BLS-01).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Information Sciences CCS-02	18.372	36.386	24.593	26.700	18.700	20.700	20.700	20.700	Continuing	Continuing

(U) **<u>Mission Description:</u>**

(U) This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as computational models and new mechanisms for performing computation and communication. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) Ubiquitous Computing and Human Computer Interfaces will develop information technologies for an environment where we are surrounded by computers which interact with us in mobile, intuitive fashion and enable collaborations as well as intelligent exchange of information in a seamless fashion. Architectures for nomadic software, redesigns of classical notions of operating systems of computers, and secure exchange of information over insecure channels are some of the technical challenges in this area. Database currency and management of dynamically changing worldviews is another important area of research in pervasive computing. Ubiquitous Computing will explore new man-machine interaction paradigms, based on implicit interaction where the human's intent is inferred and used to drive the interaction. This will create a more naturalistic interaction and greatly reduce the overhead for the user.

(U) The Amorphous Computing Architectures project will realize the promise and potential of nano-computational devices and materials for building computational architectures with high functionality for perennially computationally hungry and multi-mission adaptive DoD applications. The techniques for architecting, constructing, and programming computational systems from nano-devices require the development of novel methods quite different from those used currently, relying on precise interconnections of reliable parts. Architecture and functionality are best designed based on local interaction and self-assembly of devices, in 2-D or 3-D. Furthermore, the programming and use of such a system will be based on time-varying and irregular interconnections of devices. This project will develop breakthrough-enabling technologies for the construction and use of systems incorporating vast numbers of nano-devices that can be manufactured and deployed without precise control of placement or interconnect and without individual testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) In the area of Bio Futures, the combination of biology with information technologies and physical systems will open a new field of incredible potential. These technical fields have reached a capability level where the combination can enable both fundamental and applications breakthroughs. Progress in biology will be greatly aided by the ability to understand and manipulate the massive data inherent in living systems. Microelectronics and sensors have reached the level of systems sophistication and miniaturization that they can directly interface with biological cells. The fields of biological science and technology offer an understanding of systems complexity and robust operation using fundamental unreliable components, understanding that will enable new approaches for information technology, computers and electronics.

(U) The Bio Futures effort will support scientific study and experimentation, emphasizing biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes by applying statistical language modeling tools to the problems of rapid bio-sequencing. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes and accelerated discovery of gene expression and protein-protein interactions. The Bio Futures program will also support the extraction of genetic circuit data from gene chips with the goal of determining the functioning of protein expression, protein interaction and cellular function. The applications of this will be to develop techniques using information theory for rational medical drug discovery and broad-spectrum antibiotics discovery for pathogens confronting the warfighter. BioFutures efforts transfer to the new Bio/Micro/Info Systems Project (BLS-01) in FY 2002.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Biological and Amorphous Computing. ($ 9.596 Million)
  - Evaluated alternative approaches to DNA-based computing and identified the most promising research opportunities for enhancement and acceleration.
  - Explored mechanisms for sequencing of DNA-based computations.
  - Investigated the use of game theory, probabilistic methods, and amorphous computing in Information Technology (IT), for use in decision aids and time critical systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Engineered complex artificial systems and explored biological systems across different size scales using multi-disciplinary approaches.
- Explored biological inspired algorithms and models for computation.
- Investigated novel approaches to real-time biological instrumentation in support of interactive biology, including development of minimally invasive imaging tools for monitoring the state of ongoing biological experiments.

• Ubiquitous Computing and Human Computer Interfaces. ($ 8.776 Million)
- Designed and implemented a prototype interactive programming environment for pervasive computing.
- Developed architectural design for ubiquitous computing using mobile devices with multi-modal data entry.
- Created a prototype Information Grid Room (IGR) that provides invisible computing and data storage for a single user.

(U) **FY 2001 Plans:**

• Ubiquitous Computing. ($ 7.940 Million)
- Design the initial prototype of an environment manager.
- Develop the first iteration of abstraction algorithm for inferred intent.
- Demonstrate the first version of a scalable operating system on five diverse devices.
- Demonstrate self-organization of small number of heterogeneous devices.

• BioFutures. ($ 28.446 Million)

Biological and Amorphous Computing.
- Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.
- Establish focused research initiatives at the interface between biology, engineering, and information sciences.
- Demonstrate use of high resolution imaging technology and signal transduction to effect interactive control over simple biological systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Evaluate alternative approaches to the implementation of game theory, probabilistic methods, amorphous computing in decision tools and software development.

Bio:Info:Physical Systems Interface.
- Explore fault tolerant hardware architectures, software techniques with the ability to self-heal and reprogram adaptively.
- Demonstrate modeling and control of genetic circuits, expression of proteins, protein-protein interaction and cellular function for rational medical drug design.
- Develop new hybrid devices combining biological and artificial components scaling from molecular-scale to population level.
- Create biologically inspired algorithms and models for computation, possibly including systems of hybrid devices.
- Apply developments in biology, information science and materials science to dramatically improve the interactions of humans and systems.
- Explore elaborated Hidden Markov Model techniques for structural homology identification and sequence alignment in genetic circuits, and for protein expressions.
- Explore extraction-based data mining approach for discovery of intracellular protein interactions.
- Baseline protein extraction from scientific texts and interaction pairs.
- Experiment with Tree Adjoin Grammers for modeling crossed interactions in simple 3D RNA/protein motifs.

(U) **FY 2002 Plans:**

- Ubiquitous Computing. ($ 9.893 Million)
  - Deliver architecture for persistent, distributed storage.
  - Demonstrate task mobility with a small number of applications.
  - Demonstrate inferred interaction in the virtual information space with a small number of sensory inputs (gigabytes per second, Radio Frequency tags, audio, video).
  - Demonstrate delivery of information based on environmental recognition.
  - Demonstrate adaptability in two diverse environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Demonstrate scalability for nomadic data access.
- Evaluation of individual components.

• Amorphous Computing Architectures. ($ 4.700 Million)
- Develop models of defect tolerant architectures, including defect-tolerant circuit-design from nano-devices in 2-D and 3-D substrates;
- Programming methodology for amorphous computing systems: develop abstractions and techniques for obtaining desired global behavior from local interactions of unreliable basic computational units.

• BioFutures. ($ 10.000 Million)
- Demonstrate high-throughput manipulation and interrogation of biochemical and molecular features in single cells.
- Demonstrate informatics frameworks for integrating imaging and biochemical data from single cells.
- Demonstrate the application of novel nanoelectric and microphotonic devices to measure and control the output from cerebral cortex slices.
- Exploit nanoscale fluidic phenomena to achieve control of molecular level activity interrogation and control.
- Develop nanofluidic interfaces for selective transport of multi-scale bimolecules.

(U) **<u>FY 2003 Plans:</u>**

• Ubiquitous Computing. ($ 10.000 Million)
- Demonstrate scalability for network architecture.
- Demonstrate environmental resource management by varying several parameters in the environment.
- Demonstrate security features in the self-organizing network.
- Demonstrate scalability for small footprint operating systems.
- Deliver evaluation methodology.
- Integration of selected components into military testbed.
- Conduct scenario based exercise in military testbed.
- Plan refinement of technologies based on evaluation of field test in military testbed.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Amorphous Computing Architectures. ($ 6.700 Million)
  - Develop compilation strategies for amorphous computing.
  - Develop reconfiguration strategies for amorphous computational systems for dealing with defects that may arise after their construction, as they may have organic and biological matter.
  - Develop optimized run-time compilation strategy.
  - Develop methods for computationally inspired construction of structures for use in molecular electronic based architectures.
  - Develop novel algorithms using novel models of computation for amorphous computing structures.
  - Demonstrate the power of the novel architectural substrate on selected DoD applications that will benefit from this technology with special emphasis on the micro-platform dynamic multi-mission applications.

- BioFutures. ($ 10.000 Million)
  - Demonstrate the measurement of synaptic events via carbon nanotube arrays.
  - Demonstrate asynchronous stochastic hybrid system models that simulate cellular regulatory networks.
  - Demonstrate a prototype scanning single-pixel microarray microscope.
  - Develop functional nanofluidic sensors based on cells or cellular components for high sensitivity sensing.
  - Demonstrate nano-scale fluidic systems for the decoupling, quantification, and transduction of multi-scale biomolecular signatures.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Electronic Sciences ES-01	21.429	16.498	18.243	17.645	18.506	21.365	21.365	21.365	Continuing	Continuing

(U) **Mission Description**:

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) This project is also concerned with coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components critical to enhancing the effectiveness of military platforms that enable warfighter capabilities for comprehensive awareness and precision engagement, and contribute to the continued advancement of Next Generation Internet capabilities. Topics to be researched include emitters, detectors, modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Mechanical Electronics. ($ 1.832 Million)
  - Demonstrated the properties for mechanical switches that include device speed and current density scale and size, hysteretic behavior for non-volatile memory applications and reduction of threshold switching voltage to below 10V.
- Terahertz Technology. ($ 3.297 Million)
  - Continued to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation.
  - Investigated the feasibility of integrating these components to form a range of compact subsystems for applications in space-based communications, remote sensing, covert communications, and chem-bio detection.
- Microinstruments. ($ 10.809 Million)
  - Researched new technology for diagnostic instruments to support, maintain and service the warfighter and military platforms.
  - Investigated new technology concepts that support high volume/low cost wearable and hand-held diagnostic instruments.
  - Explored microinstruments "on-a-chip" concepts that integrate sensors, electronics, storage, display and actuation.
  - Evaluated microinstruments that include fluid dispensing, fluid sensing, and fluid identification important for "in-the-field" medical, chemical/biological and equipment diagnostics and repair.
  - Demonstrated a patterning microinstrument that writes a pattern of array of 50nm minimum – feature-size bits or pixels at a rate of $6cm^2$/sec over an area of $1cm^2$.
- University Opto-Centers. ($ 5.491 Million)
  - Established university opto-centers that are focused on creating new capabilities for the design, fabrication and demonstration of chip-scale modules, that integrate photonic, electronic, and Microelectromechanical Systems (MEMS) based technologies. Identified university technology research goals and modality for facilitating access by industry to these technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **FY 2001 Plans:**

- Terahertz Technology. ($ 4.588 Million)
  - Demonstrate, for the terahertz spectral region, the best semiconductor quantum-well approaches to sources, demonstrate semiconductor quantum-well detectors and identify system requirements to achieve space communications, upper-atmosphere imagery and close-operations covert communications.

- University Opto-Centers. ($ 11.910 Million)
  - Demonstrate initial chip-scale integrated photonic, electronic and MEMS modules.
  - Identify the most compelling DoD module applications and measure level of industry commitment to adopt chip-scale integration approach.

(U) **FY 2002 Plans:**

- University Opto-Centers. ($ 14.869 Million)
  - Evaluate the experimental results of the program's efforts to develop novel methods for the design, fabrication and demonstration of chip-scale modules that integrate photonic, electronic and MEMS based technologies.
  - Characterize the impact of these new technologies on applications in the areas of bio-photonics, optically addressed memory and on-chip optical interconnects.
  - Fabricate and test individual chip-level sub-assemblies for later use in prototype development.

- Terahertz Technology. ($ 3.374 Million)
  - Demonstrate compact sources and detectors capable to operate between 0.2 – 10 terahertz (THz).
  - Demonstrate terahertz, short-range detection system.
  - Assess experimental component performance and compare against system requirements for space communications, upper-atmosphere imagery, and close-operations covert communications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **FY 2003 Plans:**

- University Opto-Centers. ($ 17.645 Million)
  - Design and fabricate prototype modules using the system-on-a-chip approach developed earlier in the program.
  - Construct testbeds capable of fully measuring and characterizing the mixed technologies implemented in the chip-scale components.
  - Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Materials Sciences MS-01	26.232	37.531	22.427	25.053	27.053	19.053	19.053	19.053	Continuing	Continuing

(U) **Mission Description:**

(U) This project is concerned with fundamental research leading to the development of high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; materials and measurements for molecular-scale electronics; a new class of semiconductor electronics based on the spin degree of freedom of the electron, in addition to (or in place of) the charge; new materials discoveries; and novel methods for reducing drag in future generations of high-speed ships.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Portable Power. ($ 5.000 Million)
  - Designed, built and tested novel portable power sources that operate directly on logistics fuels.
  - Demonstrated a small (~50W) proton exchange membrane fuel cell operating on several novel hydrogen sources.
  - Demonstrated the operation of a portable direct methanol fuel cell.

- Nanoscale/Biomolecular Materials. ($ 6.744 Million)
  - Explored novel processing schemes for the formation of nanoscale/biomolecular and spin-dependent materials, interfaces, and devices.
  - Explored the capabilities of quasicrystals, amorphous metals, meta-materials, carbon nanotubes, quantum dots, and other nanostructured/biomolecular materials for enhancing the structural and functional performance of DoD systems.

- Molecular Electronics. ($ 7.888 Million)
  - Demonstrated that molecules can be chemically tuned into a desired electronic functionality.
  - Fabricated nano-wires that are electrically conductive and can be assembled into rows or columns of wires via self-assembly.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Demonstrated that molecular and/or nanostructured materials can perform a storage function that can be driven from one state to another by an external signal.

- Advanced Drag Reduction (Fast Ship). ($ 3.000 Million)
  - Conducted integrated hydrodynamic model development at multiple scales to provide foundational theory for quantitative drag prediction and drag reduction prediction.
  - Commenced laboratory-scale calibration and confirmation testing of initial model predictions.

- Nanoelectric Research. ($ 1.900 Million)
  - Continued molecular and quantum-dot cellular automata nanoelectric research.

- Spectral Hole Burning. ($ 1.700 Million)
  - Investigated the applications of spectral hole burning.

(U) **<u>FY 2001 Plans:</u>**

- Nanoscale/Biomolecular Materials. ($ 10.000 Million)
  - Demonstrate enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrate the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular/multifunctional materials and structures.
  - Explore the interface between biological systems and abiotic surfaces.

- Spin-Dependent Materials and Devices. ($ 7.000 Million)
  - Demonstrate spin-polarized transport across ferromagnetic/semiconductor interfaces.
  - Optimize spin lifetime in semiconductor structures.
  - Demonstrate spin light emitting diode (spin-LED) and spin field effect transistor (spin-FET).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Molecular Electronics. ($ 13.531 Million)
  - Demonstrate that molecules and/or nanoparticles can self-assemble into functional, regular patterns.
  - Build and test a minimum 16-bit functional, reversible molecular memory sub-unit.
  - Build and test room temperature scalable logic gates using molecules.

- Advanced Drag Reduction (Fast Ship). ($ 7.000 Million)
  - Complete integrated hydrodynamic model development at multiple scales.
  - Complete laboratory-scale calibration and confirmation testing of initial model predictions.
  - Develop model-based performance predictions of different potential drag reduction techniques.
  - Confirm drag reduction performance predictions from laboratory-scale testing.

(U) **<u>FY 2002 Plans:</u>**

- Nanoscale/Biomolecular Materials. ($ 8.400 Million)
  - Develop approaches for synthesis of nanoscale/biomolecular materials based on encoded combinatorial synthesis of polymers.
  - Develop techniques for transferring information between cells and synthetic materials.
  - Develop tools for engineering plant cells to synthesize materials in compartments (e.g., seeds) from which they can be readily purified and processed.

- Spin-Dependent Materials and Devices. ($ 12.000 Million)
  - Demonstrate spin coherent optical modulators and switches operating at frequencies approaching a teraHertz.
  - Demonstrate an optically excited spin phase-logic device operating in the gigaHertz frequency range with very low dissipation.

- First Principles Materials Discovery. ($ 2.027 Million)
  - Develop and validate first principle (ab-initio, molecular dynamics, etc.) approaches to the discovery of new materials with properties and structures of interest to DoD applications (e.g., piezo-ceramics, structural metals, magnetic materials).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **FY 2003 Plans:**

- Nanoscale/Biomolecular Materials. ($ 7.453 Million)
  - Produce and evaluate novel and/or cost-efficient materials using biological synthesis approaches.
  - Demonstrate a plant-based system for producing materials compatible with industrial processing.

- Spin-Dependent Materials and Devices. ($ 14.100 Million)
  - Demonstrate a simple high speed, low power opto-electronic network using spin coherent devices.
  - Demonstrate a very high-speed circuit using spin dependent transport devices.

- First Principles Materials Discovery. ($ 3.500 Million)
  - Synthesize materials "discovered" via first principles approaches and verify properties and structure.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost to Complete	Total Cost
Bio/Info/Micro Systems BLS-01	0.000	0.000	40.000	40.000	50.000	55.000	60.000	65.000	Continuing	Continuing

(U) Mission Description:

(U) This project will develop methods at the interface of information technology, biology and micro-systems to exploit computational properties of biological substrate at the genetic level, protein-protein interaction level, cellular level and organ level. On the biological side the program will leverage information technology to develop novel ways of modeling, characterizing and controlling in-vivo responses to rapidly changing pathogens for on-demand drug delivery. The information technology discipline will reap revolutionary advances in ways of solving otherwise computationally intractable problems, massive data storage and resilient and fault tolerant ways of software development for complex self-organizing systems. Finally, on the micro-systems side, the program will yield novel methods of self-assembly of nano-structures and devices using the computational power of biological computing elements. Four programs have been identified to date to focus the program: BioSequencing, Biological Computing, Nanoflonets, and Biointerfaces.

(U) BioSequencing will develop and apply language technology tools to critical biological problems of gene identification within sequences of base pairs, three-dimensional structure prediction from sequences, and discovery of the circuits within which protein interact to complete biological functions. The program will adapt and focus language processing tools and methods to dramatically improve overall performance for information intensive bioinformatics tasks, working toward a capability for predicting effects of pathogens and drug candidates. In addition, the program will begin to explore a leveraging of discovered bioinformatics applications of tools and methods to improve human language engineering processes such as automatic understanding and translation.

(U) The Biological Computation program will explore and exploit computing mechanisms in the bio-substrate, emphasizing cellular and molecular level processes for a variety of applications of interest to the military and, in general, for national security. The program seeks to create accurate and validated models of information processing at the cellular level. The models are intended to rapidly predict the effects of external agents and cellular environmental factors and to facilitate quick design of intervention mechanisms. Additionally, the program will investigate biological computing mechanisms and advance DNA manipulation methodologies for solving hard computational problems as well as for massive, but compact, storage.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) The goal of the Nanofluidic Biomolecular Networks (NanoFlonets) program is to demonstrate nano-scale fluidic systems for the decoupling, quantification, and transduction of multi-scale biomolecular signatures for rapid on-chip gene expression analysis, pathophysiology, pathogen detection, and bacteria and virus detection and identification.

(U) The Biointerfaces component will focus on the material and biological advances required to dramatically improve the interaction and integration of biological elements with new materials. Biointerfaces will explore fundamental properties and compatibility of biological elements with material surfaces and architectures for long term function, transduction mechanisms. This thrust will also define the optimal "currency" of information transfer between a biological element (molecule, cell, tissue, or organism) and a synthetic two- or three-dimensional material or synthetic architecture. Engineering of synthetic materials and biological systems may be used to manipulate these fundamental characteristics and optimize the integration of biological elements with synthetic materials for information collection. It is expected that significant advancements in devices that utilize or mimic biological elements will be realized including sensors, computational devices, robotics, and dynamic biological materials for force protection and medical devices.

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 2000 Accomplishments:</u>**

- Not Applicable.

(U) **<u>FY 2001 Plans:</u>**

- Not Applicable.

(U) **<u>FY 2002 Plans:</u>**

- BioSequencing. ($ 6.670 Million)
  - Experiment with induction of Hidden Markov Model (HMM) structure for string insertions, deletions, and substitutions (either base pairs or amino acids).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Explore hierarchical HMMs or other architectures for finding features, or significant subsets, in sequences (either base pairs or amino acids).
- Develop an efficient parsing algorithm for structural motif features (either RNA or protein secondary structure) based on a context free grammar.
- Derive context free grammar models of sequence evolution events such as frame shifts and transpositions.
- Develop lexicon for text extraction of protein-protein interactions, including lexicons of protein synonyms and interaction classes.
- Create initial database of protein-protein extractions in standard format for modeling intracellular protein interaction circuits.
- Develop methodology for creation of protein circuit graphs from extraction databases.
- Create a methodological pathway from sequence to structure, using language-modeling tools applicable to sequence to structure investigations.
- Conduct initial Integrated Feasibility Experiment for hypothesis generation based on methodological approach from sequence to structure.

- Biological Computation. ($ 6.670 Million)
  - Extend models of genetic circuits to include gene-protein interactions within stochastic hybrid systems approach.
  - Create infrastructure for faster bio-molecular experimentation and associated CAD tools that also facilitate DoD labs.
  - Develop computationally driven DNA tile self-assembly techniques in two-dimensions, potentially useful for arbitrary circuit design in molecular electronics and generating algorithmic sheets.
  - Explore DNA computing for large Boolean processing problems on surfaces, and applications in array analysis on bio-chips.
  - Investigate the use of DNA as a compact, massive storage mechanism, with tagging and associative search.
  - Explore the design of multi-state bio-based synthetic logic circuits for monitoring and reporting states as well as for process control.
  - Investigate models of information processing in controlled cellular networks for potential use as sensing mechanisms of interest for chem-bio defense.

- Nanofluidic Biomolecular Networks. ($ 13.330 Million)
  - Exploit nanoscale fluidic phenomena to achieve control of molecular level activity interrogation and control.
  - Develop nanofluidic interfaces for selective transport of multi-scale bimolecules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Biointerfaces. ($ 13.330 Million)
  - Examine new methods of creating materials that have improved compatibility for the long-term function of biological elements.
  - Engineer living biological circuits and fabricate materials and architectures that optimize compatibility and information transfer.
  - Examine genetic adaptations in organisms that interface with synthetic materials.
  - Develop methods to fabricate interfaces that allow one and two-way communications, smart control, longevity, and stability.
  - Create instrumentation and tools that will improve experimental validation of models that explore biological systems at interfaces.

(U) **FY 2003 Plans:**

- BioSequencing. ($ 6.670 Million)
  - Use machine learning to induce and categorize sequence features (either base pairs or amino acids).
  - Produce HMM toolkit and associated sample databases for biological sequence analysis, feature identification, and rapid homology identification.
  - Conduct competitive community evaluations of sequence analysis tools with metrics for quality of analysis of biological sequences.
  - Use machine learning to induce and categorize structural motif assemblies (either RNA or protein secondary structure).
  - Design experiments for investigation of models of antigenic or antibody variability of surface expressed proteins using context sensitive grammars.
  - Populate community database of protein-protein interactions for some organism and some functions extracted from research literature
  - Create and verify reduced graphs of several protein circuits for different biological functions.
  - Derive a qualitative model of a complete pathway from sequence to function for some organism and some function.
  - Conduct metrics based evaluations on sequence to structure mapping.

- Biological Computation. ($ 6.670 Million)
  - Implement multi-resolution models of genetic circuits, and their regulation.
  - Evaluate models based on information theoretic principle. Validate models using data; develop context specific model identification techniques; and develop library of external agent influence on cellular dynamics.
  - Develop capability to predict the influence of pathogens and external agents on cellular events and processes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Develop the ability to predicate, analyze and rapidly design intervention mechanisms, using the cellular information processing models including immunological circuit models, to counter the effects of harmful bio-chemical agents of DOD interest. Modeling tools to be aimed at orders of magnitude improvement over current techniques in speed and cost for intervention design.
- Investigate DNA computing techniques based on self-assembly to generate 3-D structure for potential application in crystallography and rational drug design, for rapid response biological warfare defense mechanisms.
- Assess the possibility of designing a 'digital human' model for a broad spectrum of applications.

• Nanofluidic Biomolecular Networks. ($ 13.330 Million)
- Develop functional nanofluidic sensors based on cells or cellular components for high sensitivity sensing.
- Demonstrate nano-scale fluidic systems for the decoupling, quantification, and transduction of multi-scale biomolecular signatures.

• Biointerfaces. ($ 13.330 Million)
- Engineer living circuits at material interfaces that examine pattern recognition information processing of biological systems.
- Explore systems complexity of biological interfaces and examine interactive processes between biological elements such as learning, perception, and memory storage (short- and long-term).
- Explore integrated biological elements with two- and three-dimensional materials for energy scavenging.
- Examine integration of biological elements (molecular motors, muscle fibers) with working actuator materials or surfaces for device applications in robotics, motors, and energy scavenging.
- Design working devices that incorporate living components as sensors, actuators, and computational devices.

(U) **<u>Other Program Funding Summary Cost:</u>**

• Not Applicable.

(U) **<u>Schedule Profile:</u>**

• Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E					
COST *(In Millions)*	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	35.425	15.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Next Generation Internet NGI-01	35.425	15.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in NGI developed testbed environments for defense-specific applications. Robustness of applications built atop diverse logical and physical infrastructure will be ensured with the development of new software and hardware tools that can automatically track and assess the inter-dependencies of physical layer resources.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Gigabit-per-second Network Connectivity. ($ 17.000 Million)
  - Implemented variable rate access technologies and prototype of distributed optical switching capability compatible with 100 Gb/s optical network.
  - Implemented streamlined Internet over wavelength division multiplexed (WDM) protocol structure, eliminating two layers of existing telecommunications infrastructure.

- Network Management. ($ 18.425 Million)
  - Developed network planning and simulation technology to meet requirements for NGI scale networks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

- Demonstrated real-time (500-msec response) monitoring and control of network resources at all levels.
- Completed interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity.
- Demonstrated information management and collaborative applications operating over NGI testbed.

(U) **FY 2001 Plans:**

• Network Architecture and Management for Robust Heterogeneous Gigabit Networks. ($ 6.900 Million)
- Develop architectural framework for ensuring maximum end-to-end system survivability.
- Prototype tool for assessing dependence of applications or networking performance on physical layer resources.
- Specify robust heterogeneous network architecture that integrates gigabit wireless, wireline and satellite communications.

• Defense Applications of Gigabit Networks. ($ 8.100 Million)
- Develop virtual radar console tied to a physical radar and remotely accessible via wide-area network.
- Demonstrate real-time, high-resolution imagery transfer over multiple streams of multi-gigabyte flows.
- Enable streaming of raw (undigitized) sensor signal over wide-area links.

(U) **FY 2002 Plans:**

• Not Applicable.

(U) **FY 2003 Plans:**

• Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

(U) **Program Change Summary:** *(In Millions)*

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	36.473	15.000	0.000	0.000
Current Budget	35.425	15.000	0.000	0.000

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects minor repricing and SBIR reprogramming.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	312.328	376.592	343.279	338.674	337.248	358.577	344.277	359.277	Continuing	Continuing
JASON ST-01	1.190	1.200	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing
Intelligent Systems and Software ST-11	71.074	88.024	68.403	44.536	65.393	68.034	68.034	68.034	Continuing	Continuing
High Performance and Global Scale Systems ST-19	159.595	152.795	116.351	142.138	141.355	155.043	155.043	165.043	Continuing	Continuing
Software Engineering Technology ST-22	16.630	17.965	18.500	19.300	19.300	19.300	0.000	0.000	0.000	N/A
Information Survivability ST-24	63.839	92.802	88.738	85.800	64.500	70.000	70.000	70.000	Continuing	Continuing
Asymmetric Threat ST-28	0.000	23.806	50.087	45.700	45.500	45.000	50.000	55.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The JASON project funds an independent group of distinguished scientists and technical researchers that provide analysis of critical national security issues.

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software intensive defense systems.

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(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The Software Engineering Technology project funds the core efforts of the Software Engineering Institute (SEI).

(U) The Information Assurance and Survivability project is developing the technology required to protect DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites.

(U) The goal of the Asymmetric Threat project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The three programs in this project are Human Identification at a Distance (HumanID), Evidence Extraction and Link Discovery (EELD), and Wargaming the Asymmetric Environment (WAE).

(U) **Program Change Summary:** (*In Millions*)	**FY2000**	**FY 2001**	**FY 2002**	**FY 2003**
Previous President's Budget	320.648	376.592	347.779	355.374
Current Budget	312.328	376.592	343.279	338.674

(U) **Change Summary Explanation:**

FY 2000	Decrease is a result of SBIR reprogramming.
FY 2002	Decrease reflects reprioritization of agency resources.
FY 2003	Decrease reflects a reprioritization of agency resources, which results in reduced emphasis on information assurance and survivability technologies.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
JASON ST-01	1.190	1.200	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project supports the JASON, an independent group of distinguished scientists and technical researchers that provides analysis of critical national security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, and other allied disciplines. The JASON process ensures senior government leaders have the full range of U.S. academic expertise available on issues critical to national security involving classified and unclassified information.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- JASON. ($ 1.190 Million)
  - Continued studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self-monitoring materials.

(U) **FY 2001 Plans:**

- JASON. ($ 1.200 Million)
  - Continue studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; advanced space based systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; and advanced signal processing.

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(U) **FY 2002 Plans:**

- JASON. ($ 1.200 Million)
  - Continue studies of interest to DoD in multiple disciplines such as: Defense against bio-warfare and protection from information attack; operational dominance concepts, including, affordable precision targeting, mobile distributed communications, and future warfare concepts; advanced space based systems; sensor technologies; battlefield information systems; advanced computing; rocket and launch technologies; supersonic laminar flow; signal processing; and the intersection of biology, information and physical systems.

(U) **FY 2003 Plans:**

- JASON. ($ 1.200 Million)
  - Continue studies of interest to DoD on issues of national security.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	71.074	88.024	68.403	44.536	65.393	68.034	68.034	68.034	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

(U) A major consideration in military missions is the ability to measure large quantities of heterogeneous data gathered from a multiplicity of sources, languages and modalities (text, speech, video, etc.). Key technical challenges lie in being able to (a) develop "dialog interaction" for warfighters to talk with computers and through these computers, to command centers in a hands-free fashion to allow the warfighter to use their hands for more critical warfighting efforts; (b) retrieve, summarize and extract information from multiple foreign language streams through the development of machine translation and automatic construction of information products; and (c) access, organize and disseminate information contained in large, dynamic, multi-media document streams. This involves developing repository techniques for rigorously registering and classifying multimedia document streams, integrating knowledge, and effectively employing statistically based techniques for extracting critical content from large volumes of data.

(U) The Situation Analysis component is comprised of the Information Management (IM) program which will develop persistent identification, registration, tracking for digital objects, to create an information representation which incorporates unique naming, descriptive hierarchical or granular organization of multi-media data streams. The IM program will develop algorithms and tools for clustering, classifying, visualizing, navigating and extracting critical data from extreme high volume sources. The greatest challenge in this project is the development of algorithms that can keep up with the rapid change of information and arrival of multiple data streams in high volume during a crisis. DARPA's IM program will provide the Defense analyst with the capability for high performance retrieval, search and extraction of data by developing repository technology as well as analysis environments in an interoperable framework. The technology developed by IM is being evaluated on testbeds for the Unified Commands.

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(U) The Situation Presentation and Interaction component is comprised of DARPA's Communicator program. Warfighters in the field are called upon to respond rapidly to a wide range of unpredictable situations that require collective actions across services and components. DARPA's Communicator program will develop the intuitive, hands-free, mobile, networked access to information and the ability to create new information for others using spoken language. The Communicator program will provide the warfighter with wireless, mobile, networked communication devices to communicate with command centers on the battlefield without touching a keyboard. Dialog interaction software distributed in a network of smart devices will use a new "dialog management and context tracking" capability to facilitate interactions among human users as well as suites of computer applications. Key technical problems to be overcome include (a) the analysis of spoken information in the context of a particular problem, (b) natural generation of information in context, and (c) anytime, anywhere intuitive access to information.

(U) The Intelligent SW for Multi-Lingual and Coalition Environments component is comprised of the Translingual Information Detection, Extraction and Summarization (TIDES) program . The TIDES program will develop machine translation ability for a set of foreign languages, at State Department Level 3 (defined as the level at which fluent communication is possible). Key new techniques for machine translation are statistically based corpus analysis tools, which enable the automatic extraction of grammar and vocabulary of foreign languages. It is expected to reduce the time required for developing level 3 knowledge by a factor of 10-15. DARPA's TIDES program will acquire and utilize knowledge through a multi-stage process of query formulation, information retrieval, document translation, topic identification, information extraction and content summarization. The key insights into the methods pioneered in TIDES come from the realization that these goals are not sequential and independent but are interrelated. This inter-dependence can be exploited by information lattices which provide both feedback and feedforward into what used to be serial processes. TIDES' lattice goals are to achieve 85 percent accuracy in topic identification, 80 percent accuracy in people, places and event identification, and 70 percent accuracy in establishing relationships among identified entities.

(U) Despite recent advances in automatic speech recognition (ASR), their utility is restricted to small to medium vocabularies, noise free environments and single speakers at a time. The Reliable Omnipresent Automatic Recognition (ROAR) program supports research on omnipresent automatic recognition and synthesis from multiple input modalities that will enhance the ability of a computer system to correctly interpret the intent of the target speaker in a variety of environments. This technology includes the fusion of gaze, gesture, lip reading, and alternative speech detection through physiological micro-sensors and airborne acoustic systems. The research will be evaluated by a series of performance tests conducted on data sets that are created from various meeting environments. These meeting environments include such challenging speech conditions as sloppy speech, noisy speech, cross talk, and speech variability due to changing emotional state and stress.

(U) The DARPA Agent Markup Language (DAML) program will develop military software tools for use on InteLink and the emerging C2Link system. The program's focus is to develop enhanced interoperability technologies that extend the reach of the World Wide Web to include

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program, sensors, and other data sources, and to enable agent-based programs to use these information sources. DAML will develop a software language that ties the information about a web resource to machine-readable semantics (ontology), including ontologies for InteLink briefings and military operations. This effort will provide new technologies for the intelligent integration of information across a wide variety of heterogeneous military sources and systems.

(U) The Rapid Knowledge Formation (RKF) program objective is to enable subject matter experts who are not Artificial Intelligence (AI) experts to build, share, and reuse large knowledge bases. RKF developed technologies will be evaluated in challenge problem experiments in the domain of biological warfare. Technology challenges to be addressed include direct knowledge entry by non-AI experts, coordinating entry of possibly overlapping and inconsistent knowledge by multiple geographically distributed individuals, and achieving a knowledge entry rate twice that of today's AI expert which also results in an enormous and comprehensive knowledge base (10^6 axioms).

(U) Under the Taskable Agent Software Kit (TASK) program, software agent creation tools will be developed that reduce the per-agent development/customization cost for advanced military systems. Software agents are a next generation of software that will be able to automatically accept abstract tasking, get needed information, decide how to solve simple problems, help the user solve difficult problems, route useful information and otherwise take action on the user's behalf. This effort will explore mathematical techniques in the areas of Control Theory, Decision Theory, and Operations Research for correctly modeling and analyzing agent environments and the behaviors of agents in these environments. Experiments will reveal the qualitative aspects of environments that favor the use of agent-based systems over object-based systems. Models derived from this program will allow the development of rigorous qualitative and quantitative comparisons of agent behaviors with respect to domain and problem features.

(U) The Human Identification at a Distance (HumanID) program is developing automated multi-modal surveillance technology for identifying humans at a distance as an enabler for protection and early warning against the Asymmetric Threat. This program is funded in the Asymmetric Threat project (ST-28) beginning in FY 2001.

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Situation Analysis. ($ 25.682 Million)
  - Demonstrated statistically based semantic analysis capabilities. Developed persistent queries for audio and video streams to detect user-defined significant events and to generate alerts.
  - Demonstrated distributed prototype of information-value-based retrieval.
  - Demonstrated scalable implementation of public and secure versions of Digital Information Pheromones (DIP) characterization of network resources.
  - Developed component theory building technologies enabling direct knowledge entry by artificial intelligence novices.
  - Demonstrated language and diagram interface, analogic reasoners, and theory explanation capabilities, as well as, developed 10-20 core theories (5K-10K axioms each).
  - Developed mathematical techniques for modeling and analyzing agent behaviors.

- Situation Presentation and Interaction. ($ 24.337 Million)
  - Specified network-based service architecture Application Program Interface's (API's) for key components of dialogue architecture.
  - Demonstrated usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80%, using metrics-based evaluation.
  - Evaluated dialog for small unit logistics demonstrated in the Listen, Communicate, Show (LCS) Marine project.
  - Expanded dialog evaluation beyond the travel scenario with method for cross task comparison.
  - Expanded dialog interaction into vehicles with initial investigation of feasibility within acoustic environment of automobiles.
  - Expanded dialog interaction with information services for more natural automatically generated dialogue and speech.
  - Developed preliminary ontology for InteLink briefings and released initial language design specifications.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 12.372 Million)
  - Developed a translingual C4I database for use in U.S. and Republic of Korea coalition operations.
  - Demonstrated with operational users an automated translation of briefing documents, cross language information retrieval (Korean and English), and speech-to-speech translation (English Korean).

- Expanded investigation into capability of providing machine translation capabilities for new language pairs with smaller sized training corpora.
- Implemented TIDES open system architecture version 0.1 providing a web-based environment to support plug-in component experiments.
- Conducted experiments involving humanitarian assistance/disaster relief/consequence management in cooperation with Third Fleet.

• Intelligent Sensor Processing (Human Identification at a Distance). ($ 6.683 Million)
- Initiated studies of candidate biometric features for human identification from a distance.
- Began generation of a database containing known biometric feature data for metric-based evaluation of candidate techniques.

• Reuse Technology Adoption Program (RTAP). ($ 2.000 Million)
- Identified technologies for definition and specification of agile components.
- Developed business model to explore ways to reduce the time to get advanced DARPA technologies into the hands of the military services.

(U) **FY 2001 Plans:**

• Situation Analysis. ($ 19.527 Million)
- Deploy scalable prototype analysis environment in defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value filtering, user defined alerting, and categorizing).
- Demonstrate secure distributed repository architecture supporting digital objects of arbitrary type.
- Demonstrate feasibility of combined translingual, multimedia context-based information retrieval.
- Demonstrate direct knowledge entry by a novice (2K axioms/month) for a military problem.

• Situation Presentation and Interaction. ($ 22.849 Million)
- Perform engineering integration of key components of dialogue architecture.
- Demonstrate and evaluate dialogue performance for Project Marine; complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.
- Demonstrate and evaluate interaction of tasks with real-time, web-based, public data.

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- Demonstrate in-vehicle dialogue for information services and navigation.
- Identify short, intermediate, and long-term core Automatic Speech Recognition (ASR) research objectives - emphasizing high risk, high yield algorithm development.
- Establish evaluation protocol and metrics for intermediate challenge problem: speech group discussion task.
- Draft protocols and metrics for main challenge problem: multi scenario dynamic meeting task.
- Evaluate multi-modal input devices: lip readers, eye gaze, gesture detectors.
- Define data types for standardization.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 26.790 Million)
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.
  - Prototype implementation of coalition intelligence integration capability demonstrating benefit of end-to-end cross-language information service.
  - Demonstrate initial summarization in English of foreign language documents using frame semantics.
  - Release initial version of comprehensive, cross-language processing architecture for componetization and eventual standardization.
  - Experiment in multilingual, intelligence services, demonstrating benefits of cross-language information extraction, detection, and summarization capabilities.
  - Demonstrate initial toolkits for rapid development of cross-language capability in minority or other new languages.

- DARPA Agent Markup Language (DAML). ($ 12.925 Million)
  - Release working versions of Briefing Tool, Search Tool, and Ontology Creation Tool on Intelink.
  - Define toolset for C2 link application of DAML technologies.
  - Experimentally test and refine tool set.

- Taskable Agent Software Kit (TASK). ($ 5.933 Million)
  - Define metrics for analysis of environmental features in military C4I system usage.
  - Perform agent-design method experiments on parametric models of agent interaction systems.

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(U) **FY 2002 Plans:**

- Situation Presentation and Interaction. ($ 8.904 Million)
  - Finalize and present to the dialog and speech communities, the evaluation protocols and metrics for heterogeneous human-computer dialog systems.
  - Transition Small Unit Logistics prototype to USMC for continued refinenment and limited production in support of the Small Unit Logistics ACTD.
  - Define and publish final (release) version of the Galaxy-II+ hub architecture for general use in the dialog systems development community.
  - Finish evaluation of commercial "smart-phone" technology vs. military-specific prototypes for cost, ruggedness, and other selection-based criteria.
  - Evaluate a follow-on research program for dialog systems.

- Intelligent Software for Multi-Lingual and Coalition Environments. ($ 19.786 Million)
  - Demonstrate methods for Machine Translation development in languages for which annotated corpora and dictionaries do not yet exist.
  - Demonstrate methods for minority language translation in a South American language related to drug intervention.
  - Develop Level-1 capability for a new language (rudimentary knowledge of the foreign language and an ability to effectively use a bilingual dictionary) in 1 month.
  - Exploration of methods for comparable as well as parallel corpora (text in two languages about the same topics, but not sentence by sentence translations of each other) in statistical machine translation and apply them in Chinese.
  - Demonstrate new story detection capability and baseline performance measures for future efforts.
  - Demonstrate bioprecursor feature extraction application using broadcast and public news about public health and related issues.
  - Demonstrate “delta” information provision (providing only what's different from before) in a portal for broadcast news.
  - Information retrieval from European language documents with English queries performs 75% as well as English Information Retrieval.
  - Demonstrate 15% improvement in monolingual information retrieval using an information web infrastructure of entities, events, and threads.

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- Demonstrate cross document, cross language summarization in multiple languages.
- Experiment in automatic biography or narrative generation using time-ordering summarization techniques.
- Demonstrate integration of topic detection, named entity extraction, and summarization in a web portal across news sources in multiple languages.
- TIDES Architecture 1.0 for plug-and-play compatibility among research components for specified end-to-end multilingual applications.
- NATO Battlefield Information Collection and Exploitation Systems (BICES) experiment in Turkish to English intelligence translation using real intelligence operators.
- Strong Angel operational prototype evaluation for RimPac '02 using real intelligence operators.

• Reliable Omnipresent Automatic Recognition (ROAR). ($ 4.000 Million)
  - Incorporate core Automatic Speech Recognition (ASR) algorithms into new robust ASR prototype.
  - Integrate state-of-the-art multi-modal input devices into defined multi-modal ASR Protocol Stack.
  - Establish data-type standards for multi-modal input devices (in support of plug-and-play and system independent design).
  - Start feasibility test number one (that is, define: protocols, participants, and metrics): use of robust ASR prototype in a simple maintenance task.
  - First evaluation of group speech discussion software: protocol and metric approval for second challenge meeting task evaluation.

• DARPA Agent Markup Language (DAML). ($ 15.882 Million)
  - Define toolset for C2 link application of DAML technologies.
  - Experimental analysis of Intelink use of DAML tools.

• Rapid Knowledge Formation. ($ 12.960 Million)
  - Demonstrate knowledge entry rate of 50K axioms/month from each of 25 subject matter experts in a biowarfare challenge problem.
  - Create complex theories using undergraduate biology and medical curricula.

• Taskable Agent Software Kit (TASK). ($ 6.871 Million)
  - Publish correct mathematical techniques for modeling and analyzing agent behaviors.

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– Perform empirical validation experiments.

(U) **FY 2003 Plans:**

- Intelligent Software for Multi-Lingual and Coalition Environments. ($ 12.000 Million)
  – Demonstrate State Department Level-1 capability for a minority language in 1 month; major world language in 1 week.
  – Demonstrate extraction of temporal information and biographical multi-document summary generation across multiple languages.
  – Demonstrate delta information provision for biographies or narratives on topics, providing updates of only what is new or different.
  – Experiment with question answering format for information access, providing summary answers rather than documents.
  – Perform experiments in reading comprehension comparing machine results to standardized 3rd grade tests for humans.
  – Information Retrieval (IR) from Chinese documents with English queries performs 75% as well as English IR.
  – Provide concept of an information web of preprocessing data on entities, events, and topic threads.
  – Demonstrate 25% improvement in translingual IR performance using an information web infrastructure of entities, events, and threads.
  – Experiment with techniques for translating new languages that exploit family and evolutionary relationships among languages.
  – Experiment with domain-independent techniques for information extraction, based on induction of types from corpora.
  – Evaluate TIDES components and architecture in end-to-end capability demonstrations involving multiple languages.
  – Evaluate TIDES components and architecture in integration test of bioprecursors collection across broadcast and other sources related to public health.
  – Demonstrate speech-to-speech translation in real time between Korean and English in 50,000 word domain.
  – Provide proof of concept prototype of wearable language tool for special forces to translate signs, maps, and local information.

- Reliable Omnipresent Automatic Recognition (ROAR). ($ 7.536 Million)
  – Demonstrate hybrid multi-modal, multi-algorithm Automatic Speech Recognition (ASR) engines functional in noisy or multi-speaker environments in which the noise and signal levels are comparable.
  – Multi-Modality fusion algorithm able to support up to six modalities on a single wearable platform.
  – Air Force initiated Air Tasking Order dialog prototype ready for evaluation.
  – Meeting task metrics and protocol standards now support head-to-head evaluation ASR systems.

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- Develop multi-modal data type standards and protocol standards for evaluation of alternative algorithms.

• DARPA Agent Markup Language (DAML). ($ 13.000 Million)
- Deploy DAML-based technology to other intelligence service providers and prototype use for command and control applications.

• Rapid Knowledge Formation. ($ 5.000 Million)
- Demonstrate building and use of an integrated knowledge base of 1 million axioms in less than one year.
- Biowarfare challenge problem and proof-of-concept knowledge base to be developed in coordination with end users for transition purposes.

• Taskable Agent Software Kit (TASK). ($ 7.000 Million)
- Deploy agent-creation tools with predictable behaviors based on mathematical techniques for modeling and analyzing agent behavior.
- Robust prototype implementations.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19					
COST (*In Millions*)	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	159.595	152.795	116.351	142.138	141.355	155.043	155.043	165.043	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of the following components:

(U) The Global Mobile Information Systems effort will enable mobile wireless users to automatically form ad hoc networks and to exchange a wide range of information both within the ad hoc network and between wireless and fixed networks. This program will develop technologies to: ensure the robust and secure operation of the network, dynamically adapt bandwidth to Radio Frequency (RF) environment, and dynamically reconfigure the network to counter jamming and to provide highest quality-of-service. The program will develop and integrate technologies and techniques at the networking, wireless link/node, and applications levels, enabling access to and utilization of the full range of services available in the Defense Information Infrastructure.

(U) The Networking component develops active networking technologies and associated network management capabilities to support a new paradigm of Internet Protocol (IP) routing and transmission and deeply networked systems. Research is coordinated with DoD, NASA, DoE, NSF, and other federal agencies.

(U) The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.

(U) The Adaptive Computing Systems (ACS) project develops new approaches to the design of computer hardware that incorporates dynamic configuration capabilities. The resultant devices will allow DoD to develop a wide variety of specialized systems by reusing a relatively small set of hardware designs, each of which can be affordably produced in high volumes. In addition, the ACS project is developing software and component level technologies for use in embedded systems that leverage novel signal processing technologies.

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(U) The Mission Specific Processing (MSP) project extends Adaptive Computing Systems (ACS) technologies to support the design of highly optimized embedded processors that are required in the most severely constrained DoD applications. The technology developed by the Mission Specific Processing (MSP) project will facilitate high performance processing in future space based and miniature systems that require extremely high processing throughput while consuming the minimum possible volume, weight, and power.

(U) The Systems Environments component develops scalable software which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications. Additionally, it will develop technology to support faster, more reliable development of software for distributed embedded software for intelligent systems. This technology will enable programmers to safely introduce cross-cutting aspects such as synchronization, fault tolerance, and memory hierarchy management into basic programs that implement intelligent software interaction with a diverse suite of sensors and actuators in real-time.

(U) The Signal Processing and Power Aware Computing component is developing: 1) software and component level technologies for use in embedded systems that leverage novel signal processing technologies; and 2) innovative power management strategies, both within the chip and at the system level.

(U) A follow-on to Defense Technology Integration efforts budgeted in previous years, the Mobile Code Software program will develop the software technology to resolve time-critical constraints in logistics and mission planning. The resource management problem will be solved via the interaction of lightweight, mobile software components using a bottom-up organization approach and negotiation as techniques for resolving ambiguities and conflicts. The technology will enable designers to build systems that operate effectively in highly decentralized environments, making maximum use of local information, providing solutions that are both good enough, and soon enough.

(U) The goal of the Systems Engineering for Miniature Devices (SEMD) program is to utilize a systems methodology for integrating miniature device technology that traditionally occurs in a disparate fashion. This research project includes the integration of existing/emerging technologies in the areas of mobility, power, sensing, actuation, communication, and computation, with a special focus on the software issues involved in controlling and programming these devices.

(U) Information Technology Expeditions will develop technologies for software programmable adaptive computing systems. These are devices whose hardware is exposed to software for changing their functionality, algorithms, and power/energy consumption. Such devices are

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important for deeply networked components such as mobile computing elements whose functionality needs to be changed depending on the applications, level of battery power and speed of response.

(U) The Mobile Autonomous Robot Software component will develop embedded software technologies for programming autonomous mobile robots. The task of explicitly programming mobile robots to operate independently in complex, dynamic environments, such as those relevant for military applications, has thus far proven intractable. Conventional, direct programming strategies attempt to micro manage all top-level goals and constraints from the bottom up. That approach has proven unacceptably brittle, since it requires accurate knowledge of every possible contingency, a priori. This program is pursuing several alternative approaches to synthesizing innate (pre-programmed) competencies with learning-derived competencies for perception and control similar to the way biological systems work. The overall goal is to enable the programming of autonomous mobile robots for real world, military missions as easily as we program assembly line robots in the auto industry.

(U) The Web-in-a-Box program will develop next generation proxy servers to monitor the global web for updates of interest to disseminate this information to the interested location, intelligently utilizing bandwidth. This concept includes development of local information repositories to provide local real-time access to critical information and serve as an archive under total loss of connectivity. The goal of the technology for the next generation proxy server is to develop algorithms for monitoring the web for updates to information already being used by the remote sites. The use of information on the local information repositories must also be analyzed to develop queries to obtain new related relevant information. In addition, algorithms will be developed for maximizing the use of the bandwidth to the remote sites and balancing the pull for information from the sites with the push of critical information to each site.

(U) The Biological and Information Sciences component will design and implement biologically inspired information storage, retrieval, and processing systems.

(U) Denial-of-service (DoS) attacks are emerging as a major threat to DoD and national infrastructure systems. These highly damaging attacks are particularly insidious because they are easily launched, require minimal privileges, and tend to escape conventional intrusion detectors since they manifest themselves as excessive resource consumption or failures. The Robust High Assurance Systems task of this project will exploit recent advances in quality-of-service (QoS) assurance technologies (such as bandwidth and processor reservation, feedback control, and dynamic adaptation) to mitigate and contain DoS attacks while assuring continuity of mission critical operations. Activities include: (1) development of a framework that allows security attributes to be explicitly considered as QoS properties and that further allows application security requirements to be balanced against its performance and dependability needs; (2) development of robust high assurance QoS mechanisms and managers that are

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resistant to compromise; (3) incorporation of trust models and security information into resource management decisions; (4) integration of intrusion detection with failure detection and performance monitoring as triggers for adaptive resource management; (5) development of robust, stable adaptation algorithms that are resistant to malicious exploitation by an attacker; (6) development of policy tools for controlling these mechanisms.

(U) The Survivable Mobile Wireless Networking project will develop the technology required to significantly enhance the survivability of mobile and wireless tactical networks. These technologies will ensure future combat networks will continue operation during attack, defeat attempts to disrupt and exploit tactical battlefield communications, and recover from damaging attacks while maintaining the security of network traffic. Additionally, these technologies will enable the secure and rapid creation of mobile and wireless communications networks within hostile environments for military operations.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Global Mobile Information Systems. ($ 13.108 Million)
  - Developed prototype of high data-rate untethered nodes incorporating adaptive link controls and frequency agile RF front end with capability to automatically adapt to available spectrum frequencies.
  - Demonstrated self-organizing, self-healing mobile wireless networks supporting Quality of Service (QoS) routing utilizing Internet and Asynchronous Transfer Mode (ATM) networks.
  - Demonstrated network security techniques, including over the air re-keying, in mobile wireless multihop network.
  - Integrated GloMo simulation models and conducted scenario simulations for mobile wireless networks (100 to 10,000 nodes).

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- Networking. ($ 33.833 Million)
  - Demonstrated use of active network approach to achieve live protocol updates within two roundtrip times.
  - Provided initial release of prototype active network toolkits for end-user stations and network elements including performance measurement capabilities.
  - Provided engineering analysis of active network performance.
  - Initiated development of new models of traffic and network applicable to varying scales of time and network sizes, which are suitable for predicting network behavior.
  - Initiated building a network measurement methodology to support near real-time prediction using modeling and simulation tools.
  - Designed and demonstrated prototype software for a digital amphitheater using a gigabit interconnectivity.

- Data Intensive Systems and Software. ($ 24.353 Million)
  - Designed processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Implemented compiler that generates code compatible with processor in memory architecture.
  - Simulated data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
  - Developed architectural framework for use of data intensive technologies in embedded applications; investigated alternative approaches to package level integration of data intensive technologies with high bandwidth sensor interfaces.

- Adaptive Computing Systems (ACS). ($ 26.810 Million)
  - Implemented initial Adaptive Computing Systems (ACS) analysis and development tools.
  - Developed high-level design entry tools/development environments for ACS, e.g., for Java, C, MatLab, Khoros.
  - Completed fabrication of single clock cycle context-switchable reconfigurable computing device.
  - Implemented ACS reference platforms and supporting development environment.
  - Demonstrated ACS self-test, diagnosis and reconfiguration for fault tolerance.
  - Published updated ACS benchmarks.

- Systems Environments. ($ 22.979 Million)
  - Released reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Released prototype operating system with partitioned resource management for strict QoS guarantees.

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- Provided a joint demonstration of QoS management software with Aegis advanced computing testbed; demonstrated interoperability of combat and Command, Control, Communications Intelligence Surveillance Reconnaissance (C4ISR) functions through over-the-horizon track correlation and engagement deconfliction; demonstrated scalable resource management to handle Theater Ballistic Missile (TBM) debris fields incorporating initial trend analysis capability to predict and prevent deadline violations.

• Signal Processing and Power Aware Computing. ($ 17.855 Million)
- Implemented prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrated use of high performance signal processing for weapon systems applications.
- Initiated Power Aware Computing and Communication (PAC/C) individual power aware technology research efforts.
- Initiated early exploration of power aware tool frameworks, databases, and metrics.
- Explored potential operational environmental effects on low power electronics.
- Developed novel architectures for reprogramming field programmable gate arrays using adaptive software.

• Defense Technology Integration. ($ 12.705 Million)

Mobile Code Software.
- Analyzed ability of autonomous software to predict, negotiate and track resource requirements under changing environment and time constraints.
- Developed strategy for the rapid assessment of computation cost of complex sets of constraints.
- Implemented software toolkit for knowbot development, generation and deployment.
- Created experimental platform for negotiation-based real-time resource management.
- Measured the real-time base-line for different negotiation protocols using the experimental platform.

Information Technology Expeditions.
- Developed architectures for secure collaboration over an unreliable and dynamic network.
- Developed power and energy aware operating systems for mobile computing elements.

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- Systems Engineering for Miniature Devices. ($ 7.952 Million)
  - Established the infrastructure to carry out integrated micro-miniature device research.
  - Developed a collaborative environment for the integrated, concurrent design of all aspects of a micro-miniature platform.

(U) **FY 2001 Plans:**

- Networking. ($ 30.246 Million)
  - Investigate alternative approaches to large-scale network engineering including simulation technology.
  - Demonstrate performance improvements of 100 percent for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  - Integrate active network capabilities into Run-Time Infrastructure (RTI) for use with high-level architecture (HLA)-compliant simulations; prepare for joint demonstration with Defense Modeling and Simulation Office (DMSO).
  - Develop models of network control suitable for on-line parameter tuning, dynamic reconfiguration, fault detection, and for meeting DoD mission critical requirements.
  - Validate modeling and simulation tools, and demonstrate predictive power of the models using measured network data.
  - Implement and demonstrate application non-specific congestion manager that coordinates and ensures fair throughput for multiple applications.
  - Test radar image enhancement using coherent processing of signals from multiple radar sources connected by a very high-speed network.
  - Investigate routing techniques for multi-path diversity, including splitting codes on several paths to ensure survivability in hostile environments.
  - Explore porting of existing network intrusion and anomaly detection techniques to mobile and wireless devices.
  - Develop survivable key management and distribution architectures to protect against compromise and enable rapid network recovery and reconstitution.
  - Design algorithms for ensuring network topology confidentiality to defeat traffic analysis, topology analysis, and wireless network denial of service attacks.
  - Explore state-of-the-art antennas, receivers, and transmitters for utilizing multiple, wireless service providers that employ different frequencies and bandwidths.

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- Data Intensive Systems and Software. ($ 16.790 Million)
  - Prototype fabrication of processor in very large scale integration (VLSI) memory components that support in situ processing of application data.
  - Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
  - Prototype demonstration of processor in memory (PIM) array.
  - Demonstrate advanced cache-based approaches for data-intensive applications.

- Adaptive Computing Systems (ACS). ($ 13.151 Million)
  - Implement final Adaptive Computing Systems (ACS) design tool suites using high level entry, e.g., for Java, C, Matlab, Khoros.
  - Demonstrate 100x – 1000x reduction in compilation time for ACS implementations.
  - Implement C compiler for hybrid chips.
  - Implement ACS/heterogeneous processing Matlab design environment.
  - Implement selected benchmark algorithms using ACS automated development environmental/tool aided design.
  - Demonstrate ACS defense system insertion for high dimensionality sonar beamforming, synthetic aperture radar (SAR), signal processing, and automatic target recognition (ATR).
  - Extend ACS development tools to support application specific integrated circuit (ASIC) development for highly constrained signal processing applications.
  - Define requirements for tool enhancements needed to implement ASICs.
  - Begin design of platform independent development tools.

- Systems Environments. ($ 29.218 Million)
  - Release prototype distributed object software with real-time Quality of Service (QoS) management.
  - Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
  - Demonstrate QoS-driven fault detection and recovery within 500 milliseconds.

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- Develop intermediate representations and mechanisms for code composition and transformation.
- Develop models, specifications, code interpretations, and implementation mechanisms for embedded systems aspects, such as timing and fault tolerance.
- Develop common graph-based program representations for software analysis.
- Develop basic software analysis and interpretation services.
- Demonstrate static, independent multi-aspect software composition.
- Develop basic partial evaluation services.
- Develop initial reusable embedded system aspect software.
- Identify suite of QoS technologies with strong potential for protection against denial-of-service attacks.
- Perform initial assessment of using intrusion detectors to trigger adaptation (detection latency, effectiveness of response, stability).

• Signal Processing and Power Aware Computing. ($ 21.346 Million)
- Demonstrate flight-capable Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system recognizing 30 target types in presence of camouflage concealment deception.
- Prototype demonstrations of power aware technologies.
- Identify potential small and medium scale power aware prototype candidates.
- Define plug-in-component parameters and metrics.
- Initiate primary power aware framework tool suite efforts and Application Program Integration (API) standardization efforts.

• Mobile Code Software. ($ 15.315 Million)
- Demonstrate and evaluate software agent's ability to approximate behavior tradeoffs and to utilize negotiation in advanced logistics scenario with a 3-second response requirement.
- Demonstrate and evaluate software agent's ability for bottom-up organization in advanced logistics scenario with 100-1,000 components.
- Prototype implementation of negotiation technology in real-time scenario with a 500 millisecond response requirement.

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- Information Technology Expeditions. ($ 7.630 Million)
  - Demonstrate adaptive reprogramming of hardware within a single clock cycle.
  - Define operating systems for deeply networked multiple intelligent devices with varying data rates and processing power.
  - Develop first order rules for data extraction and update rates for web information cached remotely.
  - Semantic rules for web information storage.

- Mobile Autonomous Robot Software. ($ 16.599 Million)
  - Prototype demonstration and experimental evaluation of integrated deliberative, reactive and learning behaviors.
  - Provide laboratory demonstration of compatible knowledge representations for reprogrammable, behavior-based control.
  - Provide laboratory demonstration of learning-derived competency propagation (robot-to-robot).
  - Provide laboratory demonstration and experimental evaluation of domain specific language-derived capabilities for directly programmed portion of the software for autonomous mobile robots.

- Biological and Information Sciences. ($ 2.500 Million)
  - Prototype demonstration of autonomously controlled sequencing of DNA-based computation.

(U) **<u>FY 2002 Plans:</u>**

- Networking. ($ 26.743 Million)
  - Develop Active Networking techniques for Distributed Simulation Interest Management, including techniques for the channelization of information and for enhanced filtering of data, resulting in the minimization of network bandwidth utilization and end-system receive-processing requirements in distributed simulations.
  - Active Enabled Intrusion Detection and Response (IDR) prototype demonstrating more flexible, adaptive, autonomous, and dynamic Intrusion Detection with detection, tracing, response, and repair functions and including integration techniques such as capability encapsulation, self-adaptation, and intruder wrapping.
  - Develop and demonstrate obfuscation techniques for mobile agents that may be executing on malicious hosts, including self-monitoring and recovery techniques for obfuscated mobile agents.

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- Design and demonstrate a flexible and dynamic control, monitoring and management environment (toolkit) using Active Networks where all managed elements support the SennComm smart environment, providing the flexibility and scalability behavior necessary to cope with the management of networks of growing size and diversity.
- Develop an active network operating system (AN OS) focused on a policy-free security architecture and availability within an active network, including inter-process (e.g., applet, servlet, execution environment) isolation within the same virtual machine.
- Demonstrate correlation of multi-gigabit per second transfer of radar signal streams from multiple sources.
- Prototype digital amphitheater application tying thousands of event participants via an integrated video portal.
- Demonstrate telepresence application with dramatically reduced processing overhead.
- Demonstrate multiple video blanket media streams and client side browsers for display of these streams.
- Develop reduced order and aggregate models of network suitable for faster prediction and control; and characterize accuracy.
- Develop the ability to predict internal and end-to-end behavior of large networks at multiple time scales and resolutions.
- Implement models and control strategies in a wide area experimental test bed network with distributed simulation capability.
- Investigate alternative control mechanisms to achieve desired service level agreements and Quality-of-Service.
- Develop models for anomaly detection, fault diagnosis, and prediction of congestion onset and dynamics in large networks.
- Develop a fast, programmable emulation capability that can facilitate on-line tests of control to assess unintended consequences.
- Design congestion manager that actively monitors and integrates short flow traffic onto adaptive flow-controlled streams.
- Create a reference implementation of auto-configuration protocols based on rapid, distributed label exchange and address conflict resolution mechanisms that do not rely on servers or pre-wired identifiers.
- Prototype advanced protocol for routing finest grained flows.
- Develop a scalable resource naming mechanism.
- Prototype application layer overlays that span multiple administrative domains.
- Design metadata for service components, sensors and devices, together with service registration mechanism.
- Demonstrate search engines for distributed services and devices.

• Systems Environments. ($ 17.000 Million)
- Develop techniques for incremental (partial, completion) software analysis.
- Develop techniques for incremental formal transformation.

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- Develop deterministic and probabilistic timing services for time-based aspects.
- Develop data persistence services.
- Demonstrate pair-wise interacting aspects and transformation strategies.

• Adaptive Computing Systems. ($ 5.000 Million)
- Continue development of platform independent development tools.
- Demonstrate the automatic generation of optimized silicon for key signal processing functions.
- Demonstrate direct mapping of high-level algorithmic descriptions to silicon.
- Verify timing estimates at algorithm level.
- Complete benchmarking of initial application specific integrated circuit (ASIC) tools. Compare results with those achieved using the traditional standard cell synthesize, place, and route design flow.

• Power Aware Computing. ($ 16.989 Million)
- Demonstrate 10X power/energy aware reduction techniques incorporating compiler, algorithms, runtime systems, and mission optimization approaches.
- Demonstrate 10X power/energy aware reduction techniques incorporating micro-architecture, input/output, memory, and component optimization approaches.
- Conduct preliminary PAC/C energy simulation/modeling framework concept demonstration.
- Select small and medium scale prototype candidates.
- Define small and medium scale prototype demonstration definition.

• Mobile Autonomous Robot Software. ($ 19.000 Million)
- Demonstrate behavior scalability on a team of 5 –10 robots.
- Demonstrate a trainable, perception-based, autonomous (indoor) navigation capability in a laboratory context.
- Integrate selected strategies on government-designated platforms.
- Demonstrate adaptive generation of complex behaviors.
- Demonstrate on-line tuning of autonomous helicopter control system.
- Demonstrate multi-sensor based, autonomous navigation.

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- Demonstrate methods for directing perceptual attention.
- Demonstrate scalable behavior control laws.
- Demonstrate robust planning using Markov decision models for plan adaptation.
- Specify "intelligence" metrics for evaluation mobile robot autonomy along with evaluation methodologies.
- Verify analysis and reporting criteria and methodologies for selected metrics.
- Conduct experiments to validate selected autonomy benchmarks.

• Web-in-a-Box. ($ 8.500 Million)
- Develop technology for monitoring the local information repository.
- Develop technology to monitor changes in global information sources.
- Develop technology for dynamic prioritization management.
- Develop technology for intelligent information delivery under changing bandwidth conditions.
- Develop technology for optimizing freshness of working set of information.

• Mobile Code Software. ($ 8.000 Million)
- Conduct experimental and theoretical investigations on phase-transition effects in constraint satisfiablity problems.
- Investigate methods for the prediction of characteristics and for the detection of proximity of phase transitions.
- Develop experimental prototypes for transition-aware constraint solvers.

• Robust High Assurance Systems. ($ 6.500 Million)
- Establish cost/benefit framework for security properties and quantitative methods for reasoning about benefits/risks of selected properties.
- Demonstrate basic capability to contain isolated DoS attacks and assure service to critical applications.
- Develop resource models that capture trust and vulnerability information; develop resource management algorithms that utilize this information in resource management decisions.
- Develop basic security architecture for key QoS enforcement mechanisms and management services.
- Integrate intrusion detection systems with failure detection and performance monitoring; demonstrate adaptive capability to maintain QoS of critical applications.

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- Survivable Mobile Wireless Networking. ($ 8.619 Million)
  - Explore communication techniques that provide node location deception and hide traffic destination locations.
  - Develop techniques to enable quality of service (QoS) reservation and management for mobile wireless networks.
  - Incorporate active networking technology to develop adaptive link-level modulation techniques.
  - Investigate new techniques for physical layer communications assurance and protection against jamming, detection, and intercept.
  - Explore network intrusion and anomaly detection techniques integrated with link layer communication and detection techniques.
  - Develop "quiet" node discovery and network creation algorithms for tactical environments.
  - Demonstrate algorithms and techniques for providing controlled sharing of medium access, providing traffic cover and patterns.
  - Investigate use of collaborating agent software to network configuration, stabilization, management, and reconstitution.
  - Create node adaptation strategies and capabilities for disconnected operation.

(U) **FY 2003 Plans:**

- Networking. ($ 24.000 Million)
  - Implement a measurement-driven, model-based, hybrid simulation emulation tool in a multi-operator network, achieving HLA compliance.
  - Demonstrate scalability and real time network behavior prediction at scales ranging from msecs to hours over a cross-country wired network, and a wireless network of 100s of nodes.
  - Demonstrate on line network controls including Quality-of-Service provisioning, dynamic reconfiguration, and on-line fielding of situation specific protocols.
  - Demonstrate 10 to 100x improvement in fault diagnosis time, over current techniques.
  - Test modeling and simulation based control in scenarios of interest to military, and emergency management.
  - Prototype routing mechanism based on late-binding of addresses without latency-prone, interactive name lookup.
  - Demonstrate 1000 device network with reduced communications overhead.
  - Demonstrate edge access devices with minimal memory footprint and soft physical interface.
  - Demonstrate integrated cmos-based high-precision localization and communication device.
  - Demonstrate dynamic service composition based on globally distributed devices and services.

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  - Develop tools for visualizing service offering and composition.
  - Demonstrate seamless service operation while supporting global mobility of users and services.

- Systems Environments. ($ 19.000 Million)
  - Develop analysis techniques for aspect interference.
  - Develop data stream control services.
  - Develop stage-based binding-time analysis tool.
  - Develop staged aspect analyzer and transformer.
  - Develop dependence-based aspect composition.
  - Demonstrate program composition services on real-time data server.

- Adaptive Computing Systems. ($ 15.000 Million)
  - Expand kernel functions supported by the extended ACS toolset.
  - Verify correct silicon compilation for the parameter space supported by the Mission Specific Processor extensions.
  - Demonstrate 10x-100x reduction in power and physical size for space based radar processing and image processing applications.
  - Continue benchmarking activities.
  - Study platform insertion opportunities and complete plans for defense system demonstrations for space based radar, communications, signal processing, and automatic target recognition (ATR).

- Power Aware Computing. ($ 17.000 Million)
  - Based on experimental data from compiler, algorithms, runtime systems, and mission optimization approaches populate the power aware component database.
  - Based on experimental data from micro-architecture, input/output, memory, and component approaches populate the power aware component database.
  - Provide a Beta release of the PAC/C energy aware simulation/modeling framework.
  - Provide power aware reductions goals for small and medium scale prototypes.
  - Continue to evaluate the impact of electromagnetic energy strategies on PAC/C approaches.

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- Mobile Autonomous Robot Software. ($ 15.000 Million)
  - Laboratory experiments using selected MARS Architectures.
  - Demonstrate software technologies that constructively manage emergent behaviors.
  - Demonstrate detection and adaptation for sensor noise/malfunction.
  - Demonstrate a software framework for multi-cue visual tracking using task graph architecture.
  - Demonstrate using learned visual dynamics as a method for increasing vision system performance.
  - Demonstrate stable execution of behavior switching and adaptation in the presence of uncertainties.
  - Demonstrate replanning and dynamic behavior adaptation.
  - Demonstrate the integration of behavioral synthesis with planning models in the run-time execution system.
  - Demonstrate support for domain specific, meta-programming.
  - Experiments to evaluate autonomous terrain navigation and obstacle avoidance using robust Markov decision planning.
  - Conduct experiments to evaluate the efficacy of imitative learning derived from human-humanoid interaction using the NASA Robonaut test bed.

- Web-in-a-Box. ($ 4.000 Million)
  - Demonstrate bandwidth utilization technology.
  - Demonstrate conversion of web pages to digital objects.
  - Demonstrate persistent queries to locate new relevant information.
  - Demonstration of prototype system in mission environment.

- Mobile Code Software. ($ 10.000 Million)
  - Develop embeddable services for transition-aware constraint solvers.
  - Demonstrate time-bounded, dynamic system synthesis using transition-aware constraint solvers.
  - Develop experimental prototype for distributed, anytime constraint solvers.

- Robust High Assurance Systems. ($ 18.138 Million)
  - Demonstrate application-specific quantifiable tradeoffs between security properties and real-time constraints.

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- Demonstrate initial capability to contain coordinated DoS attacks from multiple sources.
- Develop capability to dynamically update resource models with status information on known or potential compromises.
- Demonstrate self-resilience of QoS mechanisms to attacks that penetrate security barriers.
- Develop initial stability models and stabilization strategies for adaptation mechanisms.
- Develop two-phase adaptation strategy: preservation of mission-critical QoS followed by diagnosis and system reconstitution, reconfiguration.
- Identify mechanisms for limiting potential inadvertent attack propagation through adaptation.
- Develop initial policy specification language and management tools for setting and enforcing limits on application QoS requests.

• Survivable Mobile Wireless Networking. ($ 20.000 Million)
- Develop mobile distributed firewall architectures to allow rapid deployment of mobile networks with full enclave protection.
- Investigate mechanisms for digital watermarking of mobile wireless communications to ensure device authentication and protect against terminal compromise.
- Provide public key infrastructure support for rapid revocation of individuals, to include terminal exclusion and network reconfiguration.
- Explore the use of fixed network overlay techniques for mobile wireless networks to create fault tolerant capabilities for hostile environments.
- Initiate network intrusion and anomaly detection techniques integration with physical layer communication and detection techniques.
- Explore use of directional antennae for improved survivability of multi-hop mobile networks.
- Investigate use of out-of-theater higher bandwidth devices, such as satellites, as trusted network entities.
- Initiate integration of biometric capabilities with mobile wireless terminals for end-user authentication and authorization.
- Demonstrate internetworking of multiple mobile wireless operating at different levels of security.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

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(U) **Schedule Profile:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16.630	17.965	18.500	19.300	19.300	19.300	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project funds the technology transition activities of the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices, and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology into practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems. DARPA support for SEI ends in FY 2005.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. Planned FY 2002 focus areas are: Software Engineering Technical Practices (including Survivable Systems practices, Architecture-centered Software Engineering, and Commercial Off-The-Shelf (COTS)-Based Software Engineering); enhanced Software Engineering Management Capabilities (including integrated Capability Maturity Models (CMM) and transitioning Adoption of High Payoff Software Technologies.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Software Engineering Technical Practices. ($ 9.832 Million)
  - Defined and piloted a method for survivable network technology analysis. Developed security self-evaluation method and training. Version 1 of product line acquisition guidelines and courses made available for use by DoD. Courses for training software engineers

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in the development of COTS-based systems were made available. DoD-based data on the benefits and costs of architecture analysis methods were made available.

- Software Engineering Management Practices. ($ 4.370 Million)
  - Updated and released Capability Maturity Model Integration (CMMI) training, assessment and other products based on Government and industry use and feedback. Data made available showing the benefits, costs, and appropriate conditions for use of Team Software Process.

- Adoption of Software Technologies. ($ 2.428 Million)
  - Developed guidebook for introducing technology change into organizations. Developed additional guidance for use of metrics in software acquisition and development. Continued to provide software measurement support to all initiative work to ensure performance measures were established. Provided transition planning and measurement support to SEI maturation and transition activities.

(U) **<u>FY 2001 Plans:</u>**

- Software Engineering Technical Practices. ($ 10.450 Million)
  - Establish techniques for modeling and predicting survivability attributes of systems while they are under development. Exemplar architectures for survivable systems will be in use by DoD and industry. Standard COTS evaluation practices will be defined and in use to support the development of COTS-based systems.

- Software Engineering Management Practices. ($ 4.150 Million)
  - Support rollout and widespread use of integrated Capability Maturity Model (CMM) models; extend models to additional disciplines; document benefits and costs of using the integrated models; and prepare for revision of models based on actual experience in their use.

- Adoption of Software Technologies. ($ 3.365 Million)
  - Provide transition planning and measurement support to SEI maturation and transition activities.

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(U) **FY 2002 Plans:**

- Software Engineering Technical Practices. ($ 10.500 Million)
  - Assess technologies for modeling and predicting survivability attributes of systems and select best of breed.
- Software Engineering Management Practices. ($ 4.500 Million)
  - Implement CMM models and assess applicability and accuracy.
- Adoption of Software Technologies. ($ 3.500 Million)
  - Begin transition activities relative to standard practices.

(U) **FY 2003 Plans:**

- Software Engineering Technical Practices. ($ 11.000 Million)
  - Complete application of modeling techniques and apply them to standard COTS evaluation practices.
- Software Engineering Management Practices. ($ 5.000 Million)
  - Fully transition CMM models.
- Adoption of Software Technologies. ($ 3.300 Million)
  - Complete full transition.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Information Survivability ST-24	63.839	92.802	88.738	85.800	64.500	70.000	70.000	70.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing the technology required to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited in High Performance and Global Scale Systems (Project ST-19), Command and Control Information Systems (Project CCC-01), Information Integration Systems (Project CCC-02), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Assurance and Survivability technologies will be developed to mitigate national and defense computing infrastructure vulnerabilities that could be exploited by an information warfare enemy. Information Assurance and Survivability focuses on early prototypes of software technologies leading to protection for large-scale, heterogeneous systems usable over a wide range of performance in diverse threat environments. High confidence network-based systems will include security mechanisms and value-added security services for integration into network-based infrastructure as well as inherent protection mechanisms to allow the system to resist, repel and survive attack. High confidence computing systems will be developed that provide modular security services and mechanisms, provide high reliability for distributed computations, and allow geographically separated parts of an organization to interact as if they shared a common security perimeter. This also includes integrity mechanisms to allow damage to be detected rapidly. Intrusion tolerant systems will be developed to assure code integrity, confine malicious code, and to tolerate remaining attacks using survivable architectures. Intrusion detection systems will allow attacks on the defense infrastructure to be detected, the damage to be assessed, and appropriate response to be taken. Cyber sensor technologies will allow instrumentation of critical systems to expose indications of attack. Strategic intrusion assessment technologies will be developed to detect national security threats through correlation and analysis of observed/reported activities. Assurance and dynamic integration tools will allow security and survivability to be inserted into legacy systems, and will enable critical systems to reconfigure and survive in the face of detected threat and successful attack, setting the stage for autonomic information assurance. Autonomic systems will be developed to provide intelligent but reflexive defenses that adapt rapidly in milliseconds to block or withstand many classes of known and unknown attacks. Cyber Command and Control will create technologies to enable human-directed strategic oversight and guidance, to provide strategic information attack situation understanding, mission-critical functional impact

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assessment, and cyber course of action analysis and execution. Cyber defense increasingly requires a systems approach to effectively integrate and orchestrate information assurance and survivability technologies. Accordingly, the programs comprising the Computing Systems and Communications Technologies have been realigned. The new alignment will achieve information survivability goals previously established as well as provide additional capabilities in autonomic response, situation awareness, course of action analysis, and cyber system control.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Autonomic Information Assurance. ($ 12.292 Million)
  - Identified response selection techniques for effectively handling broad classes of unknown attacks.
  - Investigated impacts and effects of dynamic response.
  - Designed active techniques for trace-back and automated response.

- Cyber Command and Control. ($ 8.016 Million)
  - Developed initial situation analysis techniques to derive strategic attack hypotheses.
  - Prototyped dynamic retasking of sensors to acquire missing situation information.
  - Developed capabilities for analysis and execution of directly controlled strategic response elements.

- Strategic Intrusion Assessment. ($ 11.984 Million)
  - Completed initial design for hierarchical reporting structure for intrusion detection systems.
  - Developed experimental methods for filtering events of purely local significance.
  - Developed common framework for linking intrusion assessment and response components.
  - Developed workflow model supporting dynamic response capability.

- Intrusion Tolerant Systems. ($ 12.903 Million)
  - Demonstrated practical digital integrity mark technology and information dispersal to facilitate recovery and verification of important data characteristics in large electronic image files.

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- Developed several promising execution monitoring prototype tools and techniques to significantly reduce the likelihood of malicious mobile code from compromising data integrity and confidentiality.
- Identified mechanisms that rapidly distinguish intact and corrupted programs through automated verification of proof-carrying code.

• Fault Tolerant Networking. ($ 11.103 Million)
- Adapted fault tolerance techniques to the networking environment balancing redundancy for availability with security requirements.
- Investigated user capability-based resource allocation mechanisms.
- Demonstrated "push-back" techniques for denial-of-service attacks.
- Exploited of active network technology for attacker fencing.

• Dynamic Coalitions. ($ 7.241 Million)
- Investigated languages and tools for specification and analysis of complex policies and translation into enforcement mechanisms.
- Augmented existing Public Key Infrastructure (PKI) capabilities with protocols for rapid revocation of coalition member credentials.

• Computer Security ($ 0.300 Million)
- Implemented and tested a combination of robust elements to achieve high reliability for mission critical computer systems.

(U) **FY 2001 Plans:**

• Information Assurance and Survivability. ($ 92.802 Million)
- Atonomic Information Assurance.
  - Develop aggregate assurance posture specification languages.
  - Develop light autonomic systems capable of effective local adaptation.
  - Initial design for larger scale distributed autonomic defensive systems.
- Cyber Command and Control.
  - Develop preliminary attack intent inference techniques.
  - Design initial methods for strategic attack mission-level impact and damage analysis.
  - Demonstrate analysis and execution of multi-element response tactics.

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- Strategic Intrusion Assessment.
  - Design protocols to allow detectors and sensors to exchange information on their capabilities.
  - Implement initial peer-to-peer protocols allowing detection components to suppress events of purely local significance.
  - Prototype demonstration of integrated assessment and response capability.
- Intrusion Tolerant Systems.
  - Investigate market-based and value-based resource allocation mechanisms.
  - Prototype demonstration of integrity mark technology and information dispersal supporting near continuous operation during post-attack audit.
  - Beta release of certifying compilers and security proof generators and checkers.
  - Demonstrate execution monitoring techniques and tools to confine malicious mobile code.
  - Investigate new approaches to intrusion tolerance based on data, spatial, temporal and analytical redundancy and market/value-based resource allocation, instead of absolute correctness; identify relevant challenge problems.
- Fault Tolerant Networking.
  - Develop techniques to isolate corrupted or malicious network entities.
  - Investigate progress-based network resource allocation mechanisms to prevent denial-of-service.
  - Investigate trust-chain techniques for network resource allocation and protection against denial-of-service.
  - Design active techniques for traceback and automated response.
- Dynamic Coalitions.
  - Prototype protocols for negotiation of policies across coalition members.
  - Create methods for fast sender authentication, scalable key distribution for creation and rekeying of coalitions.
  - Extend existing PKI capabilities with protocols for cross certification of coalition members.
- Secure High-speed IP Networking (SHIPN).
  - Initiate development of new methods for high-speed cryptographic-mode processing to overcome deficiencies of existing schemes.
  - Investigate alternative approaches to end-system security database processing.
  - Design new security architecture for high-speed IP processing, including associated key management, traffic analysis, and covert channels.

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- -- Develop a working collaboration among the Robust Open Source Community and the Trusted Systems Technology community.
- -- Investigate the feasibility of alternative approaches to high assurance trusted implementation languages and tools. Develop specifications for the best of the alternative approaches.

(U) **FY 2002 Plans:**

• Information Assurance and Survivability. ($ 88.738 Million)

– Autonomic Information Assurance.
- -- Develop coherent estimation of distributed system state throughout complex attack sequences.
- -- Develop a coordination protocol for distributed response.
- -- Achieve critical system stability throughout computer network attack by leveraging coordinated machine-speed responses.

– Cyber Command and Control.
- -- Design and develop robust visualization and user interface framework for effective control of the cyber network.
- -- Demonstrate attack projection and real-time analysis of collective response tactics.

– Strategic Intrusion Assessment.
- -- Prototype detectors that can describe and exchange new attack patterns.
- -- Develop information correlation and analysis algorithms to detect and assess widespread attacks.
- -- Develop application-specific and effects-based detection methods.

– Intrusion Tolerant Systems.
- -- Develop an experimental intrusion tolerant database system from commercial off-the-shelf (COTS) components.
- -- Begin development of a system for automated behavior modeling of programs and information systems.
- -- Explore design of intelligent systems that can judge the trustworthiness of their computational environment and make strategy and resource allocation decisions.
- -- Design a framework for tolerating intrusions in large-scale, heterogeneous, networked computing enterprises.
- -- Develop algorithms that tolerate random, unpredictable (Byzantine) faults resulting from a class of staged, coordinated intrusions.

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- Fault Tolerant Networking.
  - Demonstrate Source Path Isolation Engine (SPIE) experimentation using Collaborative Advanced Interagency Research Network (CAIRN) and COTS Intrusion Detection System to show the trace of an attack back to its ingress point soon after attack.
  - Develop modeling framework for demonstrating control structures (based on the generic propagation mechanism and measurements) that provide the means to identify and control attacks before serious damage can occur.
  - Develop a reliable distributed system over massive networks utilizing a new verification framework and methodology for building reliable and scalable protocols, based on probabilistic techniques, for distributed systems.
  - Develop and demonstrate a system that uses Quorum-based data replication to implement a persistent, survivable data repository supporting enhanced shared data abstractions and techniques for propagating updates in a large network that is subject to malicious attacks.
  - Develop capability to provide detection of denial of service attacks on the Quality of Service (QoS) data flow and to isolate the attacking packet streams using the concept of congestion pricing in resource reservation and security of resource reservation will be enhanced against insider router attacks.
  - Demonstrate a scalable architecture and localized optimization algorithms for constructing a dynamic, topologically sensitive root context for any network topology, thus, removing the dependence of a single, fixed root content for the domain name server (DNS).
  - Develop a system of deployed passive probes and intelligent security gateways to aggregate attack statistics and determine countermeasures for response to attacks on routing protocols.
  - Explore traffic modeling techniques for countermeasures for traffic analysis and denial of service attacks in wired and wireless networks, including the development of a tool set that provides survivable real-time communication services.
  - Develop, at the local network level, a set of resource management mechanisms that can be used to protect an individual network node from faults and denial of service attacks.
  - Demonstration of a reliable ordered delivery of multicast messages and group membership services over the Collaborative Advanced Interagency Research Network demonstrating that robust fault-tolerant network protocols can support survivable operation using COTS distributed programming environments.
  - Design new, efficient algorithms for detecting attacks and faults in optical networks, including models and algorithms for cost-based approach to reserving routes and bandwidth in anticipation of attacks and faults.

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- -- Develop algorithms for path classification and selection of protocols for creation of resilient network overlays within a modular routing architecture.
- Dynamic Coalitions.
  - -- Develop extensions to team-based access controls addressing dynamic coalition membership and coalitions missions, access to coalitions resources at the task level, and modeling the use of self-limiting resource permissions that evolve with the state of mission-oriented tasks.
  - -- Develop policy analysis tools to determine effectiveness of policies and policy interactions within a coalition environment.
  - -- Develop algorithms which will remove dynamic group management bottlenecks by replacement of public-key techniques with much faster secret-key techniques, insertion of computational shortcuts, and potentially, the replacement of cryptography with secret-sharing techniques (for additional performance gains).
  - -- Develop and demonstrate several intra-domain group key management approaches for mobile subscribers, built around a decentralized, hierarchical architecture: one approach based on current IETF IPSec multicast key management proposal; a second using same approach modulated by a hysteresis interval for environments with unreliable connectivity; third, an approach using explicit handoff of security associations among key distributors; and finally, an approach using periodic rekeying.
  - -- Develop general framework for hierarchical access control, decoupling rights authorization from information and service access, resulting in enhanced coalition scalability.
  - -- Demonstrate computational complexity savings of authentication algorithms through the use of clustering.
  - -- Design, develop and integrate a new certificate cache architecture with secure group communication system.
  - -- Develop policy framework and infrastructure for specifying and enforcing security policies in a multi-party communication system, including mobile participants.
- Secure High-speed IP Networking (SHIPN).
  - -- Explore multi-level assurance architecture for high-speed routers, including both Type 1 and Type 2 cryptographic engines.
  - -- Investigate complex packet processing and associated security functions.
  - -- Design key management architecture for high-speed processing, scalability, assurance levels, and multicast.
  - -- Initiate key management acceleration via improved hardware.
  - -- Investigate key management solution incorporating multicast capability for large-scale sharing environment.
  - -- Explore security policy integration with high-speed cryptographic processing.

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- -- Investigate better protection against covert channels and traffic analysis.
- -- Demonstrate reliable database lookup capabilities for high-speed cryptographic processing.
- – Composable High Assurance Trusted Systems (CHATS).
  - -- Develop an operational prototype of the Composable High Assurance Trusted Technologies.
  - -- Develop operational capability of candidate high assurance trusted implementation language and tools.
  - -- Validate the CHATS for resistance to malicious code and other system attack techniques and methods.
  - -- Investigate the range and alternative high value applications and services needed and required to interoperate with the composable high assurance technology.
  - -- Develop protection profiles for the preferred applications and services.
  - -- Investigate alternative approaches to lifecycle management for the high assurance trusted operating systems technology. Identify the best alternatives.

(U) **FY 2003 Plans:**

- Information Assurance and Survivability. ($ 85.800 Million)
  - – Autonomic Information Assurance.
    - -- Explore limits of executing mission-critical-driven resource allocation schemes at machine speed.
    - -- Integrate autonomic capabilities with fault tolerant networking and intrusion tolerant systems.
    - -- Identify tactics of machine speed dynamic defense in computer networks.
  - – Cyber Command and Control.
    - -- Demonstrate effective cyber damage localization and mitigation analysis techniques.
    - -- Develop strategic control framework for coordinating Cyber Command and Control, executing response, and monitoring its effect.
  - – Strategic Intrusion Assessment.
    - -- Implement global information sharing mechanisms to incorporate global correlation cueing into local detection analysis.
    - -- Develop automated attack tracking and multi-detector corroboration techniques.
    - -- Develop cyber sensor coverage theories and models to support effective placement strategies.

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- Intrusion Tolerant Systems.
  - Demonstrate a comprehensive approach to intrusion tolerance in a COTS setting.
  - Prototype and evaluate a framework for tolerating intrusions in large-scale, heterogeneous, networked computing enterprises.
  - Build a distributed compositional architecture for the deployment of intrusion tolerance mechanisms implementing an explicitly stated but flexible tolerance policy.
  - Develop an integrity and availability framework that combines passive intrusion tolerance and active intrusion recovery mechanisms.
  - Demonstrate an intrusion tolerant architecture for real-time military systems.
- Fault Tolerant Networking.
  - Develop a distributed, scalable, reliable, and cost-effective architecture for an active network router that schedules node resources and dynamically reconfigures itself in response to failures.
  - Demonstrate new networking protocols, optimized to resist various strong adversaries, in an overlay network infrastructure.
  - Develop protocols to use fault tolerant consensus to ensure that all correct nodes are making consistent decisions and nodes can immediately route around failures.
  - Design and develop modifications to Source-Initiated Ad Hoc Routing Algorithm (SARA) to incorporate techniques for intrusion-resistant mechanisms for Flow-based Route Access Control, multi-path routing, and flow monitoring algorithms.
  - Specification/verification of secure multicasting based on trust algebra and threat model, followed by implementation of virtual secure networks (VSN) signaling and analysis of use and effectiveness of forward error correction (FEC) in routing and multicasting.
  - Develop revocation notification for active faulty code and diverse and compensatory authentication techniques for just-in-time authentication capabilities in active networks.
  - Demonstrate of route hardening and restoration algorithms for protection against coordinated attacks against optical networks.
  - Design distributed protocol for denial-of-service detection and demonstration of protocol in robust, secure wide-area conferencing tool for overlay capabilities to dynamically switch routing paths when under attack.
- Dynamic Coalitions.
  - Analysis of security properties and key management mechanisms in distributed trust management protocols and secure multicast protocols.
  - Develop cryptographic hardware accelerator to speed up cryptographic computations for devices used in coalition networks.

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- -- Develop reverse sandbox shell to protect code from malicious tampering by its environment, with API call interception, debugger processing, and instruction emulation for malice detection and isolation.
- -- Demonstrate integrated facilities for transitive delegation, with support for capacity sandboxing, reverse sandboxing, and object caching.
- -- Develop and demonstrate intra-domain group key management protocols extended to handle mobile key distributors within mobile networks.
- -- Design and develop a modular architecture and robust key agreement within a dynamic coalition, including reconfigurability and evaluation.

– Secure High-speed IP Networking (SHIPN).
- -- Design key management solutions requiring automated capabilities that eliminate human intervention.
- -- Demonstrate key management in concert with multiple assurance level security architecture.
- -- Explore integration of high-speed IP capability with existing network infrastructure such as firewalls, gateways, and network management functions.
- -- Demonstrate reduction in covert channels and traffic analysis vulnerabilities.
- -- Integrate new government standard Advanced Encryption Standard (AES) to provide high-speed hardware implementation.
- -- Demonstrate high-speed database processing for security association lookup and policy management functions.
- -- Test initial implementations for interoperability with legacy IP security products.
- -- Demonstrate scalable high-speed secure packet processing.
- -- Develop 1GB prototype for security and performance testing.

– Composable High Assurance Trusted Systems (CHATS).
- -- Implement prototype adaptations of the preferred applications and services as indicated by the protection profiles.
- -- Implement the composable high assurance trusted system and the adapted applications and services on candidate representative DoD mission critical system server fabric.
- -- Investigate alternative approaches for extending the composable high assurance technology to the network client fabric.
- -- Develop protection profiles for the best candidate high assurance client side trusted systems.
- -- Implement the best of the lifecycle support alternatives.
- -- Investigate the alternative technology transfer options that provide the best long term persistence and continuity for the CHATS technology and tools.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Asymmetric Threat ST-28	0.000	23.806	50.087	45.700	45.500	45.000	50.000	55.000	Continuing	Continuing

(U) **Mission Description:**

(U) The most serious threats to our national security, today, are *asymmetric* in nature. They are not threats of a conventional, force-on-force engagement by an opposing military, but threats of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. The enemy force is likely to be small – only a few individuals. The weapon is likely to be unconventional – a highly lethal chemical, biological, or information attack. The target is likely to be non-military – a vulnerable civilian facility or institution. The essence of this emerging trend is that a smaller and smaller force can have an increasingly lethal impact on our national security.

(U) This new threat brings new technological challenges. Instead of being satisfied with the capability to detect a nation-state as they prepare and execute a conventional military operation, the U.S. will need to develop a capability to detect a small, loosely organized group as they plan and execute an unconventional attack. This new threat will have a smaller mass, exhibit fewer observables, and yet will be more lethal in consequence. Sparse activity that was once too insignificant to notice will need to be detected, correlated, and understood. This can only be achieved by developing a new level of automation to detect, correlate, and understand all of the observable evidence exhibited by these sparse events. Specific needs include: the capability to automatically recognize and identify humans at a distance, to detect any enemy agent performing surveillance of a U.S. target; to automatically discover, extract, and link together sparse evidence of a group's intentions and activities from vast amounts of classified and unclassified information sources; to more precisely model the beliefs and organizational behavior of these small groups to better simulate and wargame our new opponents in this asymmetric world; and to provide more effective collaborative reasoning and decision aids to improve the speed and effectiveness of distributed teams of analysts and decision-makers in these dynamic situations.

(U) The goal of this new project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The programs in this project are Human Identification at a Distance (HumanID), Evidence Extraction and Link Discovery (EELD), Wargaming the Asymmetric Environment (WAE), and Effects Based Nonlinear Analysis and State Estimation (Endstate).

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(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal surveillance technology for identifying humans at a distance as an enabler for protection and early warning against an asymmetric threat. HumanID seeks to improve individual biometric technologies and develop methods for fusing biometric signatures from multiple sensors for multi-range, round-the-clock processing. HumanID focuses on multi-modal fusion of different biometrics techniques with focus on body parts identification, face and human kinematics, with biometric signatures acquired from video, infrared and multi-spectral sensors, and configurations of networked cameras. Biometric techniques will be examined as a function of multiple ranges and presentation time. The goal of this program is to identify humans as unique individuals (not necessarily by name) at a distance, at any time day or night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. An outgrowth of the Image Understanding for Force Protection effort, the HumanID program was funded under ST-11 in FY 2000.

(U) The objective of the Evidence Extraction and Link Discovery (EELD) program is to develop a suite of technologies to automatically extract evidence from vast amounts of unstructured textual data and then discover relationships among those extracted facts to provide advance warnings of potential terrorist activities. Recent advances in language understanding software will be exploited to provide a capability to automatically extract facts from textual message, web pages, and other unstructured data sources. These language-understanding techniques will be expanded and improved to increase the accuracy of information extraction from 60-70%, where it is today, to 90-95% so that these algorithms will be able to process vast amounts of information without human intervention.

(U) The Wargaming the Asymmetric Environment (WAE) program will provide the ability to conduct real time operational wargaming in an asymmetric environment. Current wargames are general-purpose situation-response models that do not take into account the asymmetric threat. This project will inject adversarial behavior models into a multi-sided wargame. WAE seeks to develop operational wargaming tools that allow multi-dimensional asymmetric environments and intelligent stakeholders (adversary, friendly and neutral). These will advance current techniques, which are sequential, contain generic behavior models and are limited by scripted adversary play. This will increase the commander and analyst's ability to make operational decisions and develop collaborative gaming techniques against all adversaries simultaneously.

(U) The Effects-Based Nonlinear Analysis and State Estimation (Endstate) program will provide understanding of infrastructure network interdependencies and identification of vulnerabilities and specific control options to achieve a desired effect while avoiding undesired consequences. Endstate developed technologies will compute consequences using simulations that capture nonlinear, cross-network effects; and will decrease latency time in the current state estimation process. Endstate capabilities are critical to national security because currently critical physical infrastructure dependencies are poorly understood and attack against network vulnerabilities can result in unexpected cascading effects.

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(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 2000 Accomplishments:</u>**

- Not Applicable.

(U) **<u>FY 2001 Plans:</u>**

- Human Identification at a Distance. ($ 11.896 Million)
  - Develop a fixed site, force protection system approach to identifying humans at a distance.
  - Use specific service sites as prototype models.
  - Develop evaluation methodologies and independent evaluations on human identification techniques candidates.
  - Develop and assess validity of current and future technologies to meet the proposed system needs.
  - Develop and evaluate active systems that automatically adapt to operational conditions to improve range-dependent performance for given sensors.

- Evidence Extraction and Link Discovery. ($ 5.459 Million)
  - Perform a thorough linguistic analysis of sample text corpora to determine the language characteristics of the data sources of interest to asymmetric problems.
  - Develop test problems and evaluation methods for testing new information extraction techniques.
  - Perform an analysis of past case studies of asymmetric incidents to determine the relational patterns of interest for link discovery.
  - Survey and select candidate information extraction techniques for development.

- Wargaming the Asymmetric Environment. ($ 6.451 Million)
  - Develop and cross validate asymmetric model ontology with open and classified data.
  - Statistically test advanced reasoning techniques for applicability to asymmetric threats.
  - Develop initial model set of specific known asymmetric threats.

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- Develop challenge problems and associated test criteria.
- Perform predictive modeling experiments.

(U) **FY 2002 Plans:**

- Human Identification at a Distance. ($ 15.850 Million)
  - Incorporate multiple sensors and multiple biometric approaches into system approach.
  - Consider the range, accuracy, and reliability of combinations of techniques.
  - Determine the critical factors that affect performance.
  - Increase the number of scenarios for which identification technologies can be applied.

- Evidence Extraction and Link Discovery. ($ 9.398 Million)
  - Develop candidate information extraction techniques for extracting facts from text messages, news reports, and web pages.
  - Test the extraction techniques against metric-based test problems.
  - Demonstrate an improvement in extraction performance.

- Wargaming the Asymmetric Environment. ($ 19.839 Million)
  - Conduct generalization experiments.
    - a.) Establish operational testbeds in conjunction with one or more transition partners.
    - b.) Empirically determine classes of asymmetric threats.
  - Generalize predictive models from individual to classes of asymmetric threats.

- Effects-Based Nonlinear Analysis and State Estimation (Endstate). ($ 5.000 Million)
  - Demonstrate interdependency modeling technology that reflects the high degree of nonlinear couplings across physical infrastructure networks encompassing at least 2 networks.
  - Demonstrate methods for reasoning backwards from effects to causes using high-fidelity infrastructure simulations on at least one infrastructure network of 250 or more nodes.

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(U) **FY 2003 Plans:**

- Human Identification at a Distance. ($ 11.700 Million)
  - Extend the force protection system approach by developing layered multi-modal, multi-biometric techniques to identify humans over various ranges of distances and operational requirements.
  - Pursue the most promising sensors, algorithms and combinations to transition to commercialization.
  - Develop fusion methods for biometric signatures acquired over time and at different locations for use across potential systems.

- Evidence Extraction and Link Discovery. ($ 10.000 Million)
  - Continue to develop candidate information extraction techniques for extracting facts from text messages, news reports, and web pages.
  - Test the extraction techniques against metric-based test problems.
  - Demonstrate an improvement in extraction performance.

- Wargaming the Asymmetric Environment. ($ 14.000 Million)
  - Perform operations tests through the development and validation of emulation capability for model set.
  - Support automated trade-off analysis by initiating experiments for transition planning.

- Effects-Based Nonlinear Analysis and State Estimation (Endstate). ($ 10.000 Million)
  - Demonstrate interdependency modeling technology that reflects the high degree of nonlinear couplings across physical infrastructure networks encompassing at least 5 networks (2000-5000 nodes).
  - Perform and evaluate an integrated experiment demonstrating infrastructure vulnerability option generation, considering adversary work-arounds, plus continuous state estimation across at least one infrastructure (500-1000 nodes).

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	30.000	69.282	114.196	107.000	105.000	100.000	110.000	110.000	Continuing	Continuing
Deeply Networking Systems AE-01	5.405	13.513	20.656	25.000	30.000	32.000	42.000	42.000	Continuing	Continuing
Software for Autonomous Systems AE-02	16.873	17.171	41.055	32.000	22.000	18.000	18.000	18.000	Continuing	Continuing
Software for Embedded Systems AE-03	7.722	23.821	32.700	32.000	40.000	40.000	40.000	40.000	Continuing	Continuing
Gigabyte Applications AE-04	0.000	14.777	19.785	18.000	13.000	10.000	10.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program is part of a multi-agency initiative to greatly extend the reach and effectiveness of networked computation. It is funded in the applied research budget activity because it is pursuing network and software research to facilitate the "deep networking" of computers, such as those embedded within DoD platforms and weapons. It will also conduct research to greatly increase the autonomy of those systems, so as to promote the human role from that of operator to supervisor.

(U) The Deeply Networked Systems project will extend DoD's ability to monitor and control the physical environment and will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E

(U) The Software for Autonomous Systems project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) The Software for Embedded Systems project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition.

(U) The Gigabyte Applications project is developing the technology to enable robust operation of DoD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) **Program Change Summary:** (*In Millions*)	**FY2000**	**FY 2001**	**FY 2002**	**FY 2003**
Previous President's Budget	30.000	69.282	105.196	90.000
Current Budget	30.000	69.282	114.196	107.000

(U) **Change Summary Explanation:**

FY 2002 - 03 Increases reflect expansion of research in the software for embedded systems project.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01					
COST (In Millions)	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Deeply Networking Systems AE-01	5.405	13.513	20.656	25.000	30.000	32.000	42.000	42.000	Continuing	Continuing

(U) **Mission Description:**

(U) Extending DoD's ability to monitor and control the physical environment will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

(U) Close coupling of information processing with physical processes demands new technology for the integrated modeling of software and physical systems. These models will enable designers to capture complex cross cutting physical constraints that the embedded software must satisfy. The Model-Based Integration of Embedded Software component of this project will use integrated models to analyze and verify the aggregate behavior of software and physical processes, and to automatically customize, integrate system components.

(U) The large scale networking of embedded and autonomous devices creates new requirements for: embedded technologies that can achieve drastic reductions in costs while being compatible with a wide range of network and computation media; flexible mechanisms for naming, addressing, configuring and administering communication and computation resources; and system design technology which shifts the emphasis from static verification and validation to dynamic behavior guarantees. These challenges are addressed in the Networked Embedded Systems component of this project.

(U) Future defense uses of the network will have an increased emphasis on the direct exchange of real-time sensor-derived information among autonomous embedded devices. This reflects a significant change in network traffic from the present environment, which is dominated by the exchange of symbolic information among human users. The architectures and protocols needed to effect this transition will be investigated in the Networked Embedded Systems component of this project.

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Networked Embedded Systems. ($ 5.405 Million)
  - Investigated new modeling methods capturing physical constraints in embedded systems such as avionics and vetronics.
  - Developed customizable modeling tools that can be rapidly adjusted to different modeling views and application domains.
  - Investigated new generation technology with capability to configure, customize and synthesize software directly from models.

(U) **FY 2001 Plans:**

- Model-Based Integration of Embedded Software. ($ 9.925 Million)
  - Develop modeling tools that can manage overlapping modeling views.
  - Investigate methods for the mathematical modeling and composition of model-based software generators.
  - Develop customizable frameworks for embedded software.
  - Demonstrate the rapid synthesis of embedded systems using customizable frameworks and model-based generators.

- Networked Embedded Systems. ($ 3.588 Million)
  - Develop methods for maintaining and updating critical information (system and resource states, global time, etc.) system-wide, without centralized depository.
  - Investigate event/time triggered system synthesis methods subject to time, functional, performance, safety and security constraints.
  - Investigate design methods of embedded generators that guarantee selected behaviors of the generated systems.

(U) **FY 2002 Plans:**

- Model-Based Integration of Embedded Software. ($ 12.860 Million)
  - Develop methods to integrate different models of concurrency.
  - Demonstrate ability of propagating constraints among modeling views.

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- Investigate methods to integrate interdependent modeling views using high-level multiple view modeling languages.
- Demonstrate ability to compose multiple view models with interdependent modeling views.
- Develop hybrid modeling and analysis techniques for synchronous embedded systems.
- Develop generic components for model-based generators.
- Develop formal models for synchronous embedded software frameworks.
- Demonstrate Open Experimental Platform for embedded avionics applications and for vehicular electronics applications.
- Demonstrate ability to multiple view modeling of a complete embedded application on the Open Experimental Platform.
- Demonstrate ability to customize Open Experimental Platform components by using model-based generation.
- Demonstrate that composability has been achieved for dynamics, synchronization, dependability and physical characteristics.

• Networked Embedded Systems. ($ 7.796 Million)
  - Develop scalable, lightweight, fault tolerant coordination-services (time, consensus, synchronization and replication) for network embedded software technology applications.
  - Investigate deterministic and probabilistic methods for self-stabilizing protocols.
  - Investigate design approaches for the customization of coordination-services.
  - Develop formal modeling and verification techniques for coordination-services.
  - Develop formal modeling methods for integrated coordination service packages.
  - Investigate methods for the aggregation and automatic composition of coordination services.
  - Develop low-cost, open-experimental platforms for network embedded software technology.
  - Demonstrate scalability and fault resilience of basic coordination service components in simple network embedded software technology applications.

(U) **FY 2003 Plans:**

• Model-Based Integration of Embedded Software. ($ 17.000 Million)
  - Demonstrate ability to verify multiple-view models.
  - Develop methods to compose model-based generators by using generator modeling and model-based composition techniques.
  - Demonstrate ability to synthesize generators from formal specifications.

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- Demonstrate ability to model framework constraints.
- Develop formal mapping among synchronous embedded software frameworks.
- Demonstrate ability to customize multiple frameworks from models.
- Demonstrate ability to generate interface code to couple frameworks.
- Develop domain specific models and generators for medium complexity avionics applications.
- Demonstrate superior performance of generated avionics applications on the avionics Open Experimental Platform.
- Develop domain specific models and generators for medium complexity automotive applications.
- Demonstrate superior performance of generated automotive applications on the automotive Open Experimental Platform.

• Networked Embedded Systems. ($ 8.000 Million)
- Develop customizable and adaptable solutions for coordination-services for network embedded software technology applications.
- Extend self-stabilization approaches to hybrid systems.
- Develop formal models and formal verification of coordination service components.
- Develop tools for the automatic composition and verification of optimized coordination service packages.
- Demonstrate the synthesis of an optimized coordination service package on the experimental platform such as distributed avionics or space-based phased array antenna.
- Demonstrate the application design process and evaluate performance up to a 10^3 node system.
- Demonstrate ability to dynamic re-synthesis of the application under time limit using distributed constraint solvers.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Software for Autonomous Systems AE-02	16.873	17.171	41.055	32.000	22.000	18.000	18.000	18.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops software to enable predictable, safe, and cooperative operation of a free ranging, autonomous systems. This effort includes software for selected mobile robots performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. (It especially includes the operation of large numbers of small, resource constrained, cooperating robots.) Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, some autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) Autonomous systems will enable revolutionary, asymmetric military capabilities, such as the ability to autonomously convey military payloads (both lethal and non-lethal) to any portion of the battlefield without requiring human operators and the ability to autonomously retrieve, process and deliver information.

(U) The Common Software for Autonomous Robotics component of this project will develop a combination of critical, enabling software technologies that can be reused across a wide range of mobile autonomous robotic systems.

(U) The Software Enabled Control component will leverage increased processor and memory capacity to vastly increase the user's ability to maintain control over mobile devices through the development of novel techniques, such as: predictive mode changes, dynamic control scheduling, composable coordinated control, and dynamic sensor and actuator allocation.

(U) The Agent Based Negotiation component will enable the autonomous operation of large collections of agents negotiating real-time resource allocation issues, such as those encountered in logistics and countermeasures.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Common Software for Autonomous Robotics. ($ 6.734 Million)
  - Developed architectures for the integration of deliberative, reactive and learning behaviors, including knowledge representations.
  - Demonstrated alternative approaches to off-line learning.
  - Demonstrated rapid sensor-motor mapping.
  - Demonstrated "engineered" behaviors.
  - Demonstrated "statistical" control.

- Software Enabled Control. ($ 6.950 Million)
  - Specified architecture for a hybrid control system that synthesizes the control law approach with computationally-enabled mode logic scalable to very large state spaces of 100K+ states.
  - Developed active transition control and joint mode logic/control law designs.
  - Designed services for active model creation, augmentation, and query.

- Agent Based Negotiation. ($ 3.189 Million)
  - Developed framework for bottom-up organization of autonomous software.
  - Defined strategy for tasking and consolidation of responses from large numbers (thousands) of software agents with minimal human intervention.

(U) **FY 2001 Plans:**

- Common Software for Autonomous Robotics. ($ 4.963 Million)
  - Experimental evaluation of networking protocols for distributed robot controls that are more energy efficient than conventional implementations.

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- Prototype demonstration and experimental evaluation of software for distributed robotics capable of coordinating the operation of 10+ robotic devices in a collective task.

• Software Enabled Control. ($ 9.727 Million)
- Alpha-level prototype implementation of multi-mode control architecture and framework.
- Develop predictive active model framework.
- Develop parametric predictive and adaptive control frameworks.
- Complete multi-level, multi-modal advanced design tools.

• Agent Based Negotiation. ($ 2.481 Million)
- Prototype demonstration of autonomous software ability to utilize negotiation in logistics scenario.
- Develop analysis strategy for predicting global behavior of large negotiating teams.

(U) **FY 2002 Plans:**

• Common Software for Autonomous Robotics. ($ 7.914 Million)
- Demonstrate energy-saving protocols with at least 70 percent savings over conventional protocol implementations.
- Integrate developmental network protocols into selected Distributed Robots platforms.
- Evaluate developmental network protocols using the representative robot platforms in representative mission scenarios.
- Integrate natural, implicit communications modes into selected Distributed Robots platforms.
- Evaluate implicit communications modes using selected Distributed Robots platforms in representative mission scenarios.
- Evaluate "world-embedded" user interfaces.

• Software Enabled Control. ($ 19.291 Million)
- Release prototype framework for multi-system hybrid (discrete + continuous) control coordination.

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- Develop hybrid stability and transition management services.
- Develop basis for merging hybrid control and reactive robust control strategies.
- Develop baseline sensor and actuator resource services.
- Develop certification techniques for multi-modal control system (single systems).

• Agent Based Negotiation. ($ 13.850 Million)
- Demonstrate ability to identify and characterize autonomous negotiation targets needed for negotiated cooperation.
- Demonstrate ability for hierarchical coalition formation.
- Demonstrate negotiation protocols for large, hierarchically organized coalitions.
- Integrate utility for the selection of negotiation strategies.
- Demonstrate stable goal tracking ability under changing environment.
- Demonstrate avoidance of conflict by changing plans.
- Prototype implementation and evaluation of negotiation in real-time mission planning.
- Prototype implementation of adaptive scans scheduling using negotiation protocols.
- Demonstrate ability to negotiate tasks in electronic countermeasures and common challenge problems in less than 20 minutes.

(U) **FY 2003 Plans:**

• Common Software for Autonomous Robotics. ($ 4.500 Million)
- Conduct field experiments using selected Distributed Robot platforms.
- Demonstrate realistic mission scenarios using representative platforms in a simulated mission context.

• Software Enabled Control. ($ 19.000 Million)
- Integrate coordinated hybrid system services into Open Control Platform middleware.
- Integrate multi-system hybrid prediction and transition control into Open Control Platform.

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- Integrate active state model data services into Open Control Platform.
- Integrate software customization and sensor/actuator resource services into Open Control Platform.
- Lab demonstration of coordinated flight with coupled system dynamics.
- Develop flight qualification tools for coordinated multi-modal control system (single and multi-system).

• Agent Based Negotiation. ($ 8.500 Million)
- Demonstrate ability of autonomous negotiation targets (ANTs) to resolve conflict under time limit by re-negotiating plans or modifying goals.
- Demonstrate ability of ANTs to maintain stability in changing environment.
- Final Demonstration: coordinated, superior response in real-time ECM simulation.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03					
COST (*In Millions*)	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Software for Embedded Systems AE-03	7.722	23.821	32.700	32.000	40.000	40.000	40.000	40.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition.

(U) Harnessing the full potential of micro-sensors and embedded devices requires addressing new information technology challenges. Networking these untethered devices creates new requirements on hardware and software, including rapid self-assembly, timely acquisition, processing and exchange of sensor data, and energy efficient operation. Accurate identification of events and collection of information require new ways of cooperation among these devices to process physical world signals, and to integrate information in the network. Additionally, remote querying and accessing data collected by the sensor net should be simple, with easy to use interfaces.

(U) This project will build on Software and Networking R&D activities, extending and specializing them to geographically distributed micro-sensor networks. A major challenge is the development of software technologies that spans a variety of sensor nets, on ground and water, on buildings and bodies. Another challenge is to design reliable networked embedded systems retaining only supervisory control, while automating traditional "in-the-loop" tasks. The sensor tasking, data collection, integration and analysis must be fully automated to enable operation within time constraints far shorter than could be achieved by human operators.

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(U) Complex software systems must be able to reconfigure and evolve themselves dynamically, while operating. This project will develop the dynamic gauges or measures of composability necessary to enable software components from any source to support assured applications (Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA)). Outputs from this program will ensure that the critical properties of complex, heterogeneous software systems are maintained during and after composition, adaptation and deployment.

(U) The High Confidence Embedded Software (HiCES) project will provide mission critical defense applications with the tools needed for functional correctness, fault tolerance, time-critical response, security, and survivability. For complex embedded software efforts this project will develop software design tools to guarantee composability, measures of confidence, and design methods (including composition and decomposition) to achieve correctness by construction. The goal of this project is to develop software engineering tools that incorporate ubiquitous, application based, and risk-based assurance by construction, so as to reduce the effort, time and cost of assurance and quality certification processes.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2000 Accomplishments:</u>

- Large Scale Networks of Sensors. ($ 7.722 Million)
  - Identified diffusion-based approaches to networking, and aggregation and distribution of information from large numbers of multi-taskable sensor nodes.
  - Explored low-latency system designs; develop experimental platform and simulation capability.
  - Developed methods for collaborative signal processing and information integration.
  - Investigated use of declarative interfaces for tasking and querying of networked embedded systems; develop experimental prototype based on relational database query technology and lightweight operating environment.

(U) <u>FY 2001 Plans:</u>

- Large Scale Networks of Sensors. ($ 16.873 Million)
  - Implement experimental prototype supporting automated aggregation and distribution of sensor derived information involving at least 50 nodes and 100 sensors.

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- Investigate methods for efficient interoperation of fixed and mobile sensors.
- Implement networked detection, estimation, tracking, and information integration.
- Demonstrate multi-node sensor network software and benefits of collaborative signal processing for military operations such as fast moving target detection and urban operations.
- Prototype demonstration using declarative interfaces for tasking and querying of multi-taskable sensor networks.
- Specify interfaces supporting common run-time services required by signal processing and generation applications.

• Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA). ($ 6.948 Million)
- Conduct preliminary demonstrations of dynamic software component composability with multiple standard communication (e.g. Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), Distributed Computing Environment (DCE)) or Structuring (e.g., Extended Markup Language (XML), Resource Description Framework (RDF), Document Object Model (DOM)) infrastructures.

(U) **FY 2002 Plans:**

• Large Scale Sensor Networks. ($ 21.818 Million)
- Optimize embedded node processing and protocols to achieve minimum latency in military sensor networks.
- Develop and implement techniques for obtaining application specific quality of service that accommodates needed mission variations among latency, power, scalability, and reliability.
- Implement techniques for rapid self-management for ad hoc and dynamic sensor networks.
- Implement protocols for effective interoperation between fixed sensor devices and mobile devices on robots, vehicles, UAVs, and personnel.
- Develop lightweight security technology for information assurance suitable ad hoc wireless sensor networks.
- Develop multi-tiered architecture and supporting software for integrated operation of sensor devices with diverse capabilities: from miniature tags to higher functionality devices with multi-modal on-board sensors.
- Complete modeling and simulation capability scalable to large sensor networks.
- Develop engineering principles for deployment of sensor networks in specific DoD contexts, including determination of the right network size, density of nodes, sensor suite, node and link capacity, and incremental deployment.

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- Implement technology for rapid specialization, customization, and distribution of sensor network embedded software for varied DoD applications of interest to military, intelligence, and emergency management; this includes techniques for rapid mission specific configuration of hardware on the shelf to mobile code during operation.
- Optimize application specific distributed computing software for collaborative signal processing including detection, classification, and tracking for a range of military applications.
- Initiate joint experimentation with relevant DoD agencies for application of distributed micro sensor networks.
- Engage Intelligence, Emergency, and National Guard end users in joint experimentation to demonstrate new paradigms for sensing threats.
- Investigate techniques, and extend the use embedded sensor network software, for networked operation of distributed chem/bio sensors to detect and track chem/bio plumes.
- Investigate and incorporate techniques from software radio for adaptive communication in sensor networks.

- Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA). ($ 10.882 Million)
  - Demonstrate a "toolkit" of software components/gauges to:
    - determine the suitability of components for insertion / (re)use in a given system.
    - enable safe run-time composition and deployment.
    - enable continual monitoring of the system to guide adaptation.
    - ensure that critical (user defined) properties are maintained during and after composition, adaptation, and deployment.
  - Solicit inputs from DoD agencies to conduct experiments based on planning efforts and preliminary demonstrations.

(U) **FY 2003 Plans:**

- Large Scale Sensor Networks. ($ 10.000 Million)
  - Complete the development of optimized embedded software for sensor networks that is versatile, but can be rapidly specialized and tailored to mission specific deployments.
  - Implement a dynamically tasked, multi-mission capable large sensor network with 200 fixed nodes, 20 mobile nodes, 500 sensors, at least six sensing modalities, deployed over several square kms, for weeks of autonomous operation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

- Demonstrate the use of modeling of simulation technology for quick design and analysis of mission specific sensor networks.
- Demonstrate low cost networked micro sensor technology for low latency detection, classification, and precision tracking of ground moving targets; this includes interoperation of ground sensor network with airborne platforms.
- Demonstrate ad hoc sensor network deployment for military operations in urban terrain (MOUT) operations and Emergency management. Scenarios including building seize and search; fire, vehicle, metal, personnel, chem.-bio detection; rapid context assessment.
- Demonstrate, using ad hoc and mobile sensor devices, speaker detection in a crowd.
- Demonstrate chem.-bio plume detection and tracking.

• Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA). ($ 12.000 Million)
  - Apply most promising results from technology development projects (and their products) to further integrate technologies and to scale them to work on realistic DoD systems.
  - Initiate a limited number of experiments (2 to 3) funded at a level sufficient to provide meaningful results to potential DoD customers for transition planning.

• High Confidence Embedded Software. ($ 10.000 Million)
  - Develop programming languages, tools and environments for specifying, measuring and analyzing behavioral properties such as dependability, reliability, safety, security, timeliness, availability, robustness and survivability of computationally intensive systems.
  - Furnish methods for enforcing specific behaviors or constraints to be sustained in a computing environment, in a nominal or adverse environment.
  - Develop techniques of embedded software developments that are more predictably tolerant of damage, specified behavioral failures, and malicious attack.
  - Develop techniques for embedded software design which replace total dependence on testing by correct-by-construction methods.
  - Apply the developed techniques on a number of defense relevant demonstration pilots in avionics, MEMS and photonics based adaptive computing systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-04					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Gigabyte Applications AE-04	0.000	14.777	19.785	18.000	13.000	10.000	10.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing the technology to enable robust operation of DoD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) The efforts will leverage some of the advances made within earlier programs, such as the Next Generation Internet for high-speed communications and networking, but will largely target breakthroughs in DoD focused gigabyte applications, in gigabyte dataflows over wireless as well as wireline infrastructure, and in enhancing the robustness of these heterogeneous links and resources. Advances in architectural work and tools in ultra-high-performance heterogeneous flow-based communications will be pursued to enable a large number of end applications with extremely diverse traffic characteristics – expected for DoD supporting applications - to be simultaneously deployed. With the optical communications techniques that can now support many hundreds of Gigabits Per Second (Gbps) data transfer over terrestrial fiber cables, there exists today a huge bandwidth gap between wireless and wired link capability. In the Gigabit Multi-Link component of this project, new gigabit per second communication capabilities over alternate physical media will be demonstrated such that gigabyte flow transfers can be demonstrated to sites lacking in fiber infrastructure and connectivity. Multi-channel techniques in temporal, spatial, and spectral domains will be invoked to enable the new capabilities.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-04

(U) **FY 2001 Plans:**

- Ultra-High Performance Heterogeneous Flow-Based Communications. ($ 7.300 Million)
  - Develop software and physical interfaces that can adapt or be programmed to support diverse link protocols, symbol rates and signaling technologies.
  - Demonstrate gateway technology that can segregate long flows from short flows.
  - Prototype implementation for transparent, vertical handoff between flow-based and circuit-based connectivities.

- Gigabit Multi-Link. ($ 7.477 Million)
  - Demonstrate an order of magnitude increase in wireless spectral efficiency for non-mobile end nodes.
  - Establish feasibility of 10 Gbps transmission over 10km free-space link.
  - Demonstrate adaptive multi-link coding technique to enhance immunity to degradations due to mobility or environmental (weather, obstruction) changes.

(U) **FY 2002 Plans:**

- Ultra High-Performance Access. ($ 10.000 Million)
  - Prototype 40 Gbps interface card for network and sensor IO.
  - Design secure communication interfaces for gigabit-end flows.
  - Demonstrate scaling of port controller speeds by an order of magnitude.
  - Develop and demonstrate optical access nodes based on fast tunable-channel transmitters.
  - Demonstrate gigabit wireless router that uses adaptive protocols.
  - Prototype quality of service-based resource management algorithms for adaptive gigabit wireless routers.

- Real-Time Gigabit Flow Applications. ($ 9.785 Million)
  - Demonstrate correlation of multi-gigabit per second transfer of radar signal streams from multiple sources.
  - Prototype digital amphitheater application tying thousands of event participants via an integrated video portal.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-04

- Demonstrate telepresence application with dramatically reduced processing overhead.
- Construct a portable node with multi-gigabit wireless interfaces.

(U) **FY 2003 Plans:**

- Multimodal Access. ($ 9.000 Million)
  - Develop integrated architecture that combines simultaneous and adaptive non-fiber based access with fiber-based access.
  - Demonstrate optimized applications performance over integrated wide-area circuit-switched and packet-switched optical network.
  - Demonstrate Space-Time Multi-In Multi-Out (MIMO) system with optimal space-time codes and signaling strategy.

- Enhanced Applications Performance. ($ 9.000 Million)
  - Optimize and tune end-to-end wide area network performance for 80 Gbps end-to-end flows.
  - Demonstrate enhanced serving and receiving of 3D video streams with at least twenty remote sites.
  - Demonstrate the 1 Gbps MIMO system in an outdoor environment.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	125.466	162.064	140.180	149.000	169.000	173.000	173.000	173.000	Continuing	Continuing
Biological Warfare Defense Program BW-01	125.466	162.064	140.180	149.000	169.000	173.000	173.000	173.000	Continuing	Continuing

(U) **Mission Description:**

(U) DARPA's Biological Warfare Defense project is budgeted in the Applied Research Budget Activity because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, toxin, and chemical stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprises a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to significantly reduce this mismatch. This project funds programs supporting revolutionary new approaches to biological warfare (BW) defense and does not duplicate efforts of other government organizations.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), countermeasures to stop pathogen and chemical consequence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific sensors, advanced decontamination and neutralization techniques, consequence management tools, and integrated defensive systems. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include developing a new class of antibiotics targeted to enzymes essential to bacterial pathogen survival, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
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(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other pathogens (including those of non-BW origin), and identify the pathogen even in the absence of recognizable clinical signs and symptoms (i.e., while the pathogen numbers are still low).

(U) The ability to rapidly detect biological warfare agents on the battlefield with a low false-alarm rate is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby potentially saving over half the time required for identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats, determine live vs. inactivated threat status, and report functional consequences of exposure (mechanisms of action). The use of organisms such as insects are also being explored as information collectors for environmental biological or chemical threats. A variety of applications for these sensors are being explored including protection of buildings from a biowarfare agent attack.

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. This project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

(U) DARPA is working with a number of governmental organizations to exploit recent advances in high throughput genetic sequencers to obtain complete genetic information on a number of important pathogens and their non-pathogenic nearest neighbors. This will allow us to develop

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an inventory of genes and proteins that distinguish pathogens from non-pathogens and to identify pathogenic markers in any guise. This information will be used to provide superior molecular targets and enable new generations of detectors, diagnostics, and therapeutics.

(U) DARPA is developing technologies for integrated defensive systems to be employed in buildings to protect inhabitants and enhance the capability to decontaminate exposed surfaces. In addition to advanced sensors, DARPA is pursuing low-pressure-drop filters, advanced decontamination and neutralization techniques, and fate and transport models to predict agent location and lethality.

(U) Lastly, DARPA is sponsoring two one-year investigations in FY 2000. The first is a technology that uses a new material (aerogel) for the collection of agents of biological origin. Aerogel is a term used to describe very low-density, highly porous, polymeric materials that provide a highly efficient, lightweight collection medium for airborne particles. The second is a proof-of-principle program evaluating the potential of delivery immune system enhancement via inhalation for defense against BW threats.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Anti-Virals/Immunizations. ($ 16.999 Million)
  - Identified broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.
  - Developed technologies for rapid design and development of new vaccines against novel pathogens.
  - Demonstrated (in-vitro) candidate anti-viral, small molecule therapeutics for selected targets.
  - Demonstrated (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.

- Anti-Bacterials/Anti-Toxins. ($ 17.065 Million)
  - Developed (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Validated the efficacy (in-vivo) of antagonists to toxin receptors, toxin catalytic sites, and cellular platforms for toxin destruction.
  - Demonstrated (in-vivo) the efficacy of a broad-spectrum bacterial antagonist.
  - Used gene-shuffling techniques to generate molecules screened for superantigenic properties.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Multi-Purpose. ($ 16.466 Million)
  - Explored concepts for therapeutics against bioregulators and other mid-spectrum agents.
  - Identified primary harmful immune responses to biological warfare (BW) agents.
  - Explored concepts for optimizing human immune response to BW agents, minimizing negative sequelae.
  - Demonstrated in laboratory animal models the ability of modified stem cells to prevent disease.
  - Identified monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Identified polyvalent inhibitors for inhibiting pathogens on the surface of target cells in-vivo.

- External Protection. ($ 17.137 Million)
  - Developed decoy molecules that prevent the adhesion of multiple pathogenic toxins or viruses in-vivo.
  - Demonstrated (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.
  - Demonstrated initial performance of a prototype device for the purification of water contaminated with BW agent simulants.
  - Explored high throughput methods for the purification of contaminated air.
  - Demonstrated effectiveness of specific personnel protective toxin and pathogen neutralization strategies against virulent biological agents.

- Advanced Diagnostics. ($ 15.792 Million)
  - Continued identification and development of probes to be used in diagnosis systems and began testing of probe panels in the laboratory.
  - Developed sample preparation techniques to optimize speed, accuracy, and reliability of diagnosis.
  - Identified one or more promising strategies for rapid detection based on bodily responses or other biomarkers (including cytokines) to provide early indication of infection or exposure (including non-invasive early detection of disease [e.g., nitric oxide in exhaled breath]).
  - Determined feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determined feasibility of rapid single molecule DNA sequencing for accelerated patient diagnosis.
  - Explored concepts for diagnosing patients for bio-regulator and other mid-spectrum agent attack.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Sensors. ($ 21.507 Million)
  - Completed, tested and verified first-generation prototype of live agent biochip sensor.
  - Completed development of air sampling technology for airborne biological material.
  - Continued development of effective and rapid chip-reading capability with enhanced sensitivity.
  - Continued the development of unique signatures for bio-agents in mass spectrometry identification.
  - Developed biosensor technology for next-generation (bioengineered) threat agents.
  - Developed methods for identifying bioregulator-based BW agents.
  - Explored options (e.g., training, genetic engineering, etc.) for the use of invertebrates in the detection of BW agents and associated chemicals.
  - Constructed cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
  - Investigated optimal system designs for deployment of a single cell and tissue based biosensor, which incorporated environmental sampling, microfluidics, and automated detection.
  - Evaluated cell and tissue based informatics from temporal and spatial signals in cell and tissue-based sensors.
  - Explored shelf-stabilization strategies for cells and tissues.
  - Began development and optimization of bio-agent sensors and other technologies for use in building protection (fate and transport).
  - Evaluated the capability to predict flow of airborne bio-agents in and around buildings.
  - Began the development of neutralization and decontamination techniques appropriate to buildings.

- Genetic Sequencing of Biological Warfare Agents. ($ 4.000 Million)
  - Developed inventory of DoD-relevant BW agent pathogens requiring sequencing.
  - Determined best methods for rapidly sequencing biological warfare pathogens and related species and strains.
  - Began development of database mining techniques to find new targets for sensors, diagnostics, and therapeutics.

- Consequence Management. ($ 10.000 Million)
  - Developed distributed BW consequence management smart checklists for automatic pull and push of required information.
  - Continued development of Enhanced Consequence Management Planning and Support System (ENCOMPASS) software toolkit.
  - Developed automated checklists for BW attacks and incorporated Incident Command System capabilities.
  - Demonstrated use of ENCOMPASS for OCONUS air base force protection against a BW attack.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Demonstrated use of playbooks and automated checklists for training BW incident responders.
- Integrated Consequence Assessment Tool Set (CATS) with Electronic Watchboard using the ENCOMPASS architecture.

• Asymmetrical Protocols for Biological Warfare Defense. ($ 3.500 Million)
- Developed recommendation regarding whether cytokines are promising for further inhalational formulation development.

• Aerogel. ($ 3.000 Million)
- Investigated capture efficiency as a function of aerogel porosity.
- Developed aerogel coatings with greater flexibility and adherence to mass spectrometer tape.

(U) **FY 2001 Plans:**

• Anti-Virals/Immunizations. ($ 21.300 Million)
- Test and validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
- Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
- Demonstrate efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
- Demonstrate (in-vivo) the rapid design and development of new vaccines (or therapeutics) against unidentified or unknown pathogens.
- Demonstrate broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.

• Anti-Bacterials/Anti-Toxins. ($ 21.658 Million)
- Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.
- Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial pathogen antagonist.
- Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
- Demonstrate (in-vivo) efficacy of broad spectrum, superantigenic, antitoxin antagonists and vaccines.

• Multi-Purpose. ($ 22.200 Million)
- Develop therapeutic strategies against bioregulators and other mid-spectrum agents.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
- Develop therapeutic strategies for minimizing harmful immune responses to biological warfare agents.
- Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
- Validate polyvalent inhibitors for blocking pathogens on the surface of target cells in-vivo.
- Identify superantigens for broad protection against biological warfare agents with minimal side effects.
- Validate (in-vivo) the efficacy of subcellular pathogen response imaging for rapid detection.
- Validate technologies broadly applicable to enhance cellular therapeutics (delivery platforms) and virulence modulation (intracellular and inflammatory cascades).

• External Protection. ($ 21.000 Million)
- Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
- Demonstrate a non-aqueous advanced decontamination method.
- Demonstrate a water purification system effective against a range of biological agents (including toxins and bioregulators).
- Test initial performance of advanced sorbent materials for the purification of air contaminated with CW and BW agent simulants for individual protection.
- Build and test a prototype air purification system for collective protection for a group of soldiers.
- Begin testing of prototype protective system against non-virulent biological warfare agents, bio-toxins, and regulators.

• Advanced Diagnostics. ($ 19.350 Million)
- Test probe panels in relevant sample types including strategies for rapidly generating new/novel probes.
- Demonstrate that sample collection and/or preparation techniques do not introduce artifacts.
- Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
- Develop the capability to diagnose exposure to bio-regulator and mid-spectrum agents.
- Demonstrate, in the laboratory, the feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
- Evaluate the feasibility of additional strategies (e.g., exhaled breath) for direct identification or detection of infection without direct sample collection.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
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- Demonstrate the ability to perform accelerated patient diagnosis using a rapid single molecule DNA sequencing technique in a model system.

• Sensors. ($ 24.056 Million)

- Continue the development of effective and rapid chip-reading capability with enhanced sensitivity and low false alarm rate.
- Continue the development of advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
- Develop hierarchical biochip sensors.
- Evaluate methods for removing micro-encapsulation of disguised pathogens and/or sensing through the micro-encapsulation.
- Develop technologies required for next-generation miniature biological detectors including the use of microelectromechanical systems (MEMS), microfluidics, and mesoscopic-sized components.
- Evaluate false positive and false negative rates for systems of detectors using biomolecular cells or tissues.
- Exploit and/or mimic the olfactory sensors of biological systems for use in the detection of biological warfare agents.
- Demonstrate enhanced signal output from engineered cells and tissue based sensors and integrate information from these sensors with user interfaces for predictive responses.
- Engineer a deployable prototype cell and tissue sensor for field-testing.
- Develop biosensor models and robust characterization protocols.
- Evaluate new resonant modes for biosensors.
- Investigate standoff techniques for trigger and identification.
- Develop concepts for sensors capable of detecting biological warfare agent production in underground facilities.
- Investigate critical design parameters for advanced biologically based BW sensor.
- Demonstrate use of organisms to collect chemical and biological warfare agents in the field.
- Develop and validate comprehensive performance model for time-of-flight (TOF) mass spectrometer detection of aerosol live agents against clutter.
- Evaluate time-of-flight (TOF) mass spectrometer performance for counter-proliferation scenarios.
- Initiate the development, modeling, and validation of integrated sensor systems designed to meet detailed threat specifications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Bio/Chem Defensive Systems. ($ 10.000 Million)
  - Continue fate and transport model development in and around buildings and begin experimental evaluation.
  - Continue to develop decontamination techniques appropriate for structures.
  - Evaluate novel low-pressure-drop, broadband filter technologies.
  - Develop neutralization technologies for aerosolized agents.
  - Conduct integrated system design for protection of military buildings from bio-chem attack and begin experimental evaluation.

- Genetic Sequencing of Biological Warfare Agents. ($ 12.500 Million)
  - Complete the genomic sequencing of high-threat known and potential biowarfare agents.
  - Conclude development of database mining techniques and test on a subset of pathogenic genomes.

- Consequence Management. ($ 10.000 Million)
  - Demonstrate rapid construction and distribution of specific BW smart checklists for multiple responders.
  - Demonstrate Enhanced Consequence Management Planning and Support System (ENCOMPASS) management of multi-site BW incidents.
  - Demonstrate automatic construction of incident- and responder-specific playbooks and electronic watchboards.
  - Demonstrate use of ENCOMPASS for CONUS air base force protection against BW attacks.
  - Transition ENCOMPASS to Initial Detection Units and to Air Force Theater Battle Management Core.

(U) **FY 2002 Plans:**

- Anti-Virals/Immunizations. ($ 18.500 Million)
  - Identify new target candidates for new classes of anti-viral agents.
  - Demonstrate broad-spectrum therapeutic strategies against viral agents on the validated threat list, including smallpox.
  - Determine the feasibility of using one or more animal systems as a means of developing data sufficient to provide regulatory guidance for the approval of newly developed anti-viral agents effective against verified BW viral threats.
  - Test and validate (in-vivo) combinatorial chemistry solutions for viral infections emanating from validated threats.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Develop protocols to enable validated therapeutic products to transition to appropriate Service partner (e.g., USAMRIID).
- Develop strategies for Investigational New Drug (IND) enabling studies.

• Anti-Bacterials/Anti-Toxins. ($ 18.500 Million)
  - Demonstrate appropriate targets for anti-bacterial drug development by creating animal models immune to infection.
  - Demonstrate both targeted and broad-spectrum therapeutic strategies against bacterial agents (e.g., anthrax).
  - Determine the feasibility of using one or more animal systems as a means of developing data sufficient to provide regulatory guidance for the approval of newly developed anti-bacterial agents effective against verified BW bacterial threats.
  - Test and validate (in vivo) high-throughput screening technologies for bacterial infections emanating from validated threats.
  - Develop protocols to enable validated therapeutic products to transition to appropriate Service partner (e.g., USAMRIID).
  - Develop strategies for IND enabling studies.

• Multi-Purpose. ($ 24.000 Million)
  - Demonstrate therapeutic strategies against bioregulator and other mid-spectrum agents.
  - Identify novel opportunities to engineer metabolic response to threat agents.
  - Identify mechanisms for protection against catastrophic BW-induced shock.
  - Determine the feasibility of using one or more animal systems as a means of developing data sufficient to provide regulatory guidance for the approval of newly developed therapeutic agents effective against verified BW threats.
  - Demonstrate efficacy of subcellular pathogen response imaging for rapid detection.
  - Develop protocols to enable validated therapeutic products to transition to appropriate Service partner (e.g., immunomodulators).
  - Develop strategies for IND enabling studies.
  - Identify novel approaches to human BW threat agents harbored in plant, livestock and processed food.
  - Determine optimal strategies for altering metabolic rates of biological systems (cells, tissues, organisms) for extended performance and stability.
  - Evaluate optimal strategies for engineering metabolic rates of biological systems.

• External Protection. ($ 19.180 Million)
  - Demonstrate novel architectures for the manufacture of materials that are effective in blocking pathogens and limiting disease.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Demonstrate performance of advanced sorbent materials for the purification of air contaminated with CW and BW agent simulants for individual protection.
- Test a prototype air purification system for collective protection for a group of soldiers.
- Test individual prototype protective system against non-virulent biological warfare agents, bio-toxins, and regulators.
- Develop protocols to enable demonstrated protective products to transition to appropriate service partner.
- Demonstrate an individual water purification system that can treat any biological, chemical or natural contaminant.
- Demonstrate the ability to produce potable water from any water source (fresh, brackish, or seawater).
- Demonstrate efficacy of individual air purification carrier technologies to reduce the pressure drop by one half, increase chemical warfare effectiveness factors (50 percent) and provide inherent HEPA filtration.
- Extensive testing and demonstrations of gas mask filter technologies against a full array of live BW and CW agents.
- Demonstrate superior sorbent materials to adsorb CW agents and toxic industrial vapors.

- Advanced Diagnostics. ($ 15.000 Million)
  - Validate strategies for rapidly generating new probe panels for relevant sample types.
  - Validate, in model systems, lead candidate strategies for rapid detection based on bodily responses or other biomarkers for early indication of infection or exposure.

- Sensors. ($ 25.000 Million)
  - Develop front end sampling modules for cell and tissue based biosensors.
  - Demonstrate utility of cell and tissue based biosensors in operationally relevant scenarios.
  - Identify and quantify the naturally occurring volatile chemicals that plants emit in response to plant and human BW pathogens.
  - Identify the signal transduction pathways, especially the initial molecular recognition events, that underlie pathogen-triggered chemical emissions by plants.
  - Develop novel molecular replacements for identification of bioagents and toxins.
  - Characterize performance of biochip sensors.
  - Extend standoff techniques for improved discrimination.
  - Continue to develop unique signatures for bio-agents in mass spectrometry identification.
  - Optimize time-of-flight (TOF) mass spectrometer detection of aerosol live agents against clutter.

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- Continue TOF mass spectrometer counter-proliferation related work.
- Complete first end-to-end performance characterization for complete sensor systems in real operational environments.

• Bio/Chem Defensive Systems. ($ 20.000 Million)
  - Continue fate and transport modeling in buildings.
  - Continue development of building-appropriate decontamination techniques.
  - Evaluate novel approaches to combined filtration/neutralization.
  - Optimize performance of integrated building protection systems against internal chemical threat.
  - Select overseas military site for full-scale demonstration.

(U) **FY 2003 Plans:**

• Anti-Virals/Immunizations. ($ 18.000 Million)
  - Down-select successful animal model system(s) and validate utility in the regulatory process for newly developed anti-viral agents against validated threat list agents.
  - Demonstrate efficacy of combinatorial chemistry solutions in combating validated threat viral infections.
  - Implement protocols to enable validated therapeutic products to transition to appropriate Service partner.
  - Implement strategies for Investigational New Drug (IND) enabling studies.

• Anti-Bacterials/Anti-Toxins. ($ 18.000 Million)
  - Down-select successful animal model system(s) and validate utility in the regulatory process for newly developed anti-bacterial agents against validated threat list agents.
  - Demonstrate efficacy of high-throughput screening technologies in evaluating bacterial infections.
  - Implement protocols to enable validated therapeutic products to transition to appropriate Service partner.
  - Implement strategies for Investigational New Drug (IND) enabling studies.

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- Multi-Purpose. ($ 29.000 Million)
  - Down-select successful animal model system(s) and validate utility in the regulatory process for newly developed therapeutic agents against validated threat list targets.
  - Demonstrate broadly applicable technologies to enhance cellular therapeutics and virulence modulation.
  - Implement protocols to enable validated therapeutic products to transition to appropriate Service partner.
  - Implement strategies for IND enabling studies.
  - Demonstrate novel approach in engineering metabolic response to threat agents.
  - Develop novel approaches to human BW threat agents harbored in plant, livestock, and processed food.
  - Develop methods for providing super normal protection from BW induced shock.
  - Engineer biological system with altered metabolic rate that demonstrates increased longevity and stability.

- External Protection. ($ 19.000 Million)
  - Demonstrate an air purification system for collective protection for a group of soldiers.
  - Demonstrate protective system against non-virulent biological warfare agents, bio-toxins, and regulators.
  - Implement protocols to enable demonstrated protective products to transition to appropriate Service partner.

- Advanced Diagnostics. ($ 15.000 Million)
  - Demonstrate strategies for rapidly generating new probe panels for relevant sample types.
  - Demonstrate, in model systems, lead candidate strategies for rapid detection based on bodily responses or other biomarkers for early indication of infection or exposure.

- Sensors. ($ 25.000 Million)
  - Develop sensitive methods for detecting volatile chemicals emitted from plants including methods based on spectroscopy as well as insect behavior.
  - Develop genetic tools to engineer natural plant responses to pathogens in ways that enhance detectability.
  - Integrate molecular replacement components into sensor systems.
  - Develop standoff bio sensor system.
  - Develop networked biosensors and algorithms for their integration to reduce false alarms.

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- Bio/Chem Defensive Systems. ($ 25.000 Million)
  - Complete development of building-appropriate filtration, neutralization, combined filtration/neutralization, and decontamination techniques, and evaluate effectiveness in building protection.
  - Evaluate systems-level building protection performance against internal chemical threat.
  - Implement, test, and optimize system components for protection against internal bio threat.
  - Initiate development of software-based planning tool to model threat and mitigation effectiveness for building protection.
  - Characterize overseas military site in preparation for full-scale demonstration.

(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	131.705	162.064	160.180	169.000
Current Budget	125.466	162.064	140.180	149.000

(U) **Change Summary Explanation:**

FY 2000	Decrease reflects SBIR reprogramming and minor program repricing.
FY 2002 - 03	Decrease reflects end of Consequence Management and Genetic Sequencing efforts in FY 2002 and end of Water Purification program in FY 2003.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	138.314	121.051	136.679	145.814	159.642	171.306	184.306	184.306	Continuing	Continuing
Naval Warfare Technology TT-03	14.374	0.000	15.000	15.000	20.000	26.200	36.200	36.200	Continuing	Continuing
Advanced Land Systems Technology TT-04	26.034	21.972	19.425	32.348	29.162	35.144	35.144	35.144	Continuing	Continuing
Advanced Tactical Technology TT-06	33.221	32.232	42.322	42.073	44.230	41.371	41.371	41.371	Continuing	Continuing
Aeronautics Technology TT-07	40.302	29.131	26.475	32.593	42.450	44.291	47.291	47.291	Continuing	Continuing
Advanced Logistics Technology TT-10	14.993	27.791	23.564	23.800	23.800	24.300	24.300	24.300	Continuing	Continuing
Joint Logistics ACTDs TT-11	9.390	9.925	9.893	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Aeronautics, and Logistics technologies.

(U) The Naval Warfare Technology project is focusing on enabling technologies for a broad range of naval requirements. Programs include High Energy Density Materials, Friction Drag Reduction, and Submarine Payloads and Sensors. The High Energy Density Materials program is exploring high risk/high pay-off breakthroughs in missile propellants and explosives technologies. The Friction Drag Reduction program will develop friction drag reduction technologies for surface ships and submersibles. The Submarine Payloads and Sensors effort will explore submersible platforms designed to maximize payload capacity.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
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(U) The Advanced Land Systems Technology project is developing technologies for enhancing the U.S. military's effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War. The NetFires program (formerly Advanced Fire Support Systems) will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Dog's Nose/Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines. The Close-In Sensing program will emphasize new approaches to detect traditionally low signal-to-signal noise or concealed targets. The Low Cost Guided Medium Caliber Projectiles program will develop affordable guidance and control technologies for 25-60mm gun launched projectiles. The Active Ballistic Imaging effort will exploit newly discovered phenomenon to facilitate surveillance and targeting in adverse weather conditions.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems; precision optics components for critical DoD applications; miniature air-launched decoy systems; affordable rapid response missile demonstrations; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems; and emerging payload delivery concepts.

(U) The Aeronautics Technology project will explore technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of a new family of Micro-Air Vehicles; Micro Adaptive Flow Control technologies; Small-Scale Propulsion System concepts; the Advanced Rotorcraft Technology program; Short Take-off and Vertical Landing Unmanned Combat Air Vehicles concepts; Ceramics for Propulsion Systems; and a one-year effort to explore Supersonic Aircraft Noise Mitigation.

(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently. The project will also develop and demonstrate advanced military-grade measures for security, robustness, and scalability to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare environments.

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(U) The Joint Logistics project, composed of two Advanced Concept Technology Demonstrations (ACTDs), will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Service logistics communities.

(U) **Program Change Summary:** (*In Millions*)

	FY2000	**FY 2001**	**FY 2002**	**FY 2003**
Previous President's Budget	142.501	121.051	126.679	151.114
Current Budget	138.314	121.051	136.679	145.814

(U) **Change Summary Explanation:**

FY 2000	Decrease reflects SBIR reprogramming and minor program realignments.
FY 2002	Increase reflects continuation of the Naval Warfare Project (TT-03) to develop Friction Drag Reduction technologies.
FY 2003	Decrease reflects reprioritization of agency requirements.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Naval Warfare Technology TT-03	14.374	0.000	15.000	15.000	20.000	26.200	36.200	36.200	Continuing	Continuing

(U) **Mission Description:**

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The principal enabling technologies include investigation into High Energy Density Materials (HEDM) for advanced explosives and propellants and innovative payload and platform concepts for expanding the envelope of operational capabilities for surface and submersible platforms.

(U) The Friction Drag Reduction program, beginning in FY 2002, will further develop friction drag reduction technologies, investigated under PE 0601101E, Project MS-01 in FY 2000/2001, for surface ships and submersibles that can be practically implemented in the operational environment. The goal is the development of radical skin friction drag reduction sustained over time periods that are operationally relevant. The primary focus of this program is on two methods known to reduce friction drag: injection of polymers or microbubbles into the flow boundary layer. The program will address, by means of computation and small-scale laboratory experiments, the practical barriers to the implementation of polymer additives and microbubbles. Other drag reduction techniques that are discovered by these investigations will also be explored.

(U) The High Energy Density Materials (HEDM) program fostered high-risk/high payoff efforts in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project investigated the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of detectability. The program expanded upon theoretical work previously sponsored by other DoD organizations and provides some high-risk excursions into materials, which are theoretically possible, but for which there is no currently known defined synthetic route.

(U) The Submarine Payloads and Sensors Program explored the possibilities that emerge when a unified set of payload and sensor concepts, operational implications, and supporting platform concepts are formulated in a balanced manner. Technology and programmatic roadmaps for the interlocking payload, sensor, combat system and platform concepts that evolve were defined as part of this effort. Mature efforts identified for further development in FY 2001 and beyond are budgeted in Program Element 0603763E, Project MRN-02.

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- High Energy Density Materials (HEDM). ($ 4.596 Million)
  - Initiated techniques to scale up synthesis of High Energy Density Materials (HEDM) to gram quantities and experimentally verified physical properties.
  - Conducted preliminary experiments related to synthesis of novel nitrogen molecules ($N_5^+ N_3^-$).
  - Continued efforts on other synthesis methods.
- Submarine Payloads and Sensors. ($ 2.778 Million)
  - Completed concept development phase, refined and finalized multiple payload and sensor concepts and associated mission concepts.
  - Defined and matured two flexible platform concepts capable of supporting multiple payload and sensor concepts.
  - Identified development roadmaps and technology risks and opportunities associated with the final system and platform concepts.
- CEROS. ($ 7.000 Million)
  - Selected projects for funding, both new efforts and follow-on development to projects selected in previous years.
  - Contracted selected projects and monitored progress of ocean related technologies of high interest to the DoD and the State of Hawaii.
  - Transitioned appropriate products to military and civilian use.

(U) **FY 2001 Plans:**

- Not Applicable.

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(U) **FY 2002 Plans:**

- Friction Drag Reduction. ($ 15.000 Million)
  - Develop methodology for scaling drag reduction results previously demonstrated in 6.1 to large scale models appropriate for predicting the drag reduction in operationally relevant systems.
  - Validate initial modeling efforts through small scale laboratory experiments.
  - Calculate drag reduction in operationally relevant systems.
  - Commence optimization and engineering of polymer and/or microbubble properties in operationally relevant configurations.
  - Commence development of large scale models.

(U) **FY 2003 Plans:**

- Friction Drag Reduction. ($ 15.000 Million)
  - Continue to validate maturing modeling efforts through small scale laboratory experiments.
  - Continue development and validation of large scale models.
  - Commence large scale modeling of operationally relevant systems.
  - Continue to optimize and engineer polymer and/or microbubble properties in operationally relevant configurations.
  - Develop and engineer practical injection systems.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Land Systems Technology TT-04	26.034	21.972	19.425	32.348	29.162	35.144	35.144	35.144	Continuing	Continuing

(U) **<u>Mission Description:</u>**

(U) This project is developing technologies for enhancing the U.S. military effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War (OOTW). This emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire. This project consists of the following main efforts: NetFires; Counter-artillery Force Protection (CFP); Dog's Nose/Unexploded Ordnance Detection; Antipersonnel Landmines Alternatives; Close-In Sensing; and Active Ballistic Imaging.

(U) The NetFires program (formerly Advanced Fire Support System) is developing and testing a containerized, platform-independent multi-mission weapon concept as a supporting element of the Future Combat System (FCS). NetFires will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, and lower life-cycle costs, while increasing survivability compared to current gun and missile artillery. NetFires will allow FCS to defeat all known threats in a system compatible with air deployability in C-130 (and smaller) aircraft and enhance the situation awareness and survivability of FCS by providing extended-range, non-line-of-sight engagements. The program will develop and demonstrate highly flexible systems including a modular, multimission precision missile, a loitering attack missile, a remotely commanded self-locating launcher, and a command and control system compatible with FCS. Beginning in FY 2001, NetFires is funded from PE 0603764E, Project LNW-03, Future Combat Systems.

(U) The Counter-artillery Force Protection (CFP) program developed concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program explored advanced sensors, munitions and deployment concepts to counter this evolving threat, including both active defense and counterforce options.

(U) The Dog's Nose/Unexploded Ordnance (UXO) Detection program developed sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors can work either singly or in conjunction with other technologies such as the hyperspectral mine detector.

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(U) The Antipersonnel Landmine Alternative (APLA) program is developing technologies that provide our warfighter with enhanced capabilities that obviate the need for antipersonnel landmines (APLs). Technologies under development include self-healing minefields (that achieve protection of antitank mines from dismounted breaches without the use of APLs) and tags with minimally guided munitions to detect, locate and rapidly engage dismounted infantry permitting the compression of critical timelines and distance constraints that limit the effectiveness of conventional indirect and direct fires.

(U) The Close-in Sensing program will develop technologies to complement our national remote sensing assets (space and airborne). The close-in sensors will exploit various phenomenologies to make robust detection, classification, and identification of time-critical targets, hardened and highly protected targets and characterization of the local radio frequency (RF) environment. The technologies developed will emphasize new approaches to detect traditionally low signal-to-noise or concealed targets.

(U) The Active Ballistic Imaging program will explore a newly discovered phenomenon that allows "seeing" through smoke, fog, and rain. This effort will conduct experiments to understand the phenomenon and develop the ultra short pulse laser technology, holographic beam control, and the fast gated imaging sensor technology.

(U) The Low Cost Guided Medium Caliber Projectiles program is focused on developing affordable guidance and control (G&C) technologies for 25-60mm gun launched projectiles. Today, missiles, rockets, some mortars, and some large caliber weapon systems have G&C components that make them precision munitions. Medium caliber guns are used primarily for line-of-sight engagements in situations where effectiveness is based on delivering high rates of fire, using a large number of rounds, to defeat a variety of targets from ground and air platforms. Potential advantages of low cost G&C systems for improving accuracy (i.e. probability of hit and probability of kill) of medium caliber gun launched projectiles include: 1) significantly reduced logistics burden associated with ammunition re-supply, 2) extended range and area of influence of medium caliber weapons, and 3) option of employing inexpensive medium caliber rounds to accomplish some missions that currently require expensive material (large caliber rounds and missiles.) The focus of this effort is on overcoming technical challenges associated with miniaturization of guidance and maneuver components, while keeping the cost per round low enough to be accepted as an affordable option. Primary program goals are to: 1) demonstrate an order of magnitude decrease in the number of rounds that must be fired to achieve the same effectiveness as current medium caliber systems, and 2) demonstrate significantly enhanced performance and effectiveness of medium guns against stationary and moving targets by enhancing accuracy and precision at range. Technical challenges include: 1) designing low cost, small guidance systems that can withstand very high G loading and projectile spin; 2) designing low cost, small, effective maneuver mechanisms to divert or correct course of the bullet in flight; and 3) devising

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inexpensive methods for testing and evaluating performance of smart bullets, since current test methods are destructive to the on-board components and gun ranges typically are not instrumented to record the bullet's behavior in flight.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- NetFires (formerly Advanced Fire Support System). ($ 12.074 Million) [Future Combat Systems – related = $12.074 Million]
  - Completed detailed design for an objective demonstration system, including launch, fire control, and each of the demonstration flight systems.
  - Tested component hardware and software.
  - Continued advanced concept feasibility assessments.
  - Initiated hardware-in-the-loop tests.
  - Awarded follow-on options for NetFires precision and loitering attack missiles, container launcher unit, and command and control modules.

- Counter-artillery Force Protection (CFP). ($ 1.006 Million)
  - In conjunction with the Army, defined one or more system architectures, including sensors, munitions and deployment to meet the mission needs for enclave protection against missile artillery.

- Unexploded Ordnance Detection. ($ 5.982 Million)
  - Continued the development of chemical sniffers for land mine detection.
  - Reduced sized, improved field response to interferents, and improved sampling system.
  - Demonstrated a condensed phase detector in the field in multiple configurations (handheld and vehicle mounted) and formalized transition with the user.

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- Antipersonnel Landmines Alternatives. ($ 6.972 Million)
  - Began preliminary development of antitank minefield healing algorithms.
  - Conducted initial experimentation of self-healing minefield subsystems – individual mine-surrogate mobility concepts and mine-to-mine communication methods.
  - Developed and demonstrated tagging concepts in the laboratory.

(U) **FY 2001 Plans:**

- Antipersonnel Landmines Alternatives. ($ 9.925 Million)
  - Conduct initial field experiments of self-healing minefield system.
  - Demonstrate autonomous location of individual mines and minefield mapping.
  - Evaluate tag communication range in field tests.
  - Demonstrate adhesion of tags in the field.

- Close-in Sensing. ($ 9.547 Million)
  - Investigate potentially promising radio frequency phenomenology collection techniques.
  - Develop novel tagging technologies.
  - Assess data exfiltration schemes.

- Active Ballistic Imaging. ($ 2.500 Million)
  - Conduct phenomenology experiment.
  - Perform preliminary system performance modeling and assessment.

(U) **FY 2002 Plans:**

- Antipersonnel Landmine Alternatives. ($ 6.925 Million)
  - Integrate final self-healing minefield system concept.
  - Build and test in field 50 mine prototypes.

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- Evaluate collective behaviors for breaching in simple minefields.
- Test surrogate tagging concepts in relay network.
- Demonstrate detection and location of surrogate tags.

• Close In Sensing. ($ 8.000 Million)
- Continue trade off studies in advanced technologies for use in data exfiltration.
- Mature novel tagging technologies.
- Begin integration designs for collection platforms.

• Low Cost Guided Medium Caliber Projectiles. ($ 4.500 Million)
- Perform system analyses and studies to determine the increase in battlefield effectiveness possible with greatly improved accuracy for medium caliber bullets.
- Determine which existing medium caliber weapons would serve as best first demonstrator and which missions would benefit most.
- Develop low cost, practical tools and test methodologies to systematically evaluate performance of integrated guidance and control packages in controlled test environments.
- Conduct studies to identify several candidate technologies/approaches and to understand challenges, risks and scaling factors for each potential concept.
- Assess challenges of miniaturizing guidance, control and maneuver packages for tactical rounds in the 25-60mm class, and impact of the gun launch environment on components.

(U) **FY 2003 Plans:**

• Close In Sensing. ($ 24.348 Million)
- Miniaturize key components of promising data exfiltration techniques for ease of emplacement.
- Demonstrate useful data exfiltration techniques and ready them for continued development and integration.
- Investigate semi-autonomous and autonomous guidance technologies for data exfiltration systems.

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- Low Cost Guided Medium Caliber Projectiles. ($ 8.000 Million)
  - Select best concepts and begin prototype component development, concentrating on miniaturization, bullet integration issues, manufacturability issues, and achieving low cost per round.
  - Conduct component level tests to verify that the guidance packages can survive the gun launch environment and that the maneuver mechanisms provide adequate course correction for bullets.
  - Select one or more candidate guidance and control system components and integrate them on projectiles of various sizes (25-60mm).
  - Perform flight demonstrations and target acquisition demonstrations.
  - Initiate efforts that will result in tactical design(s) and fabrication of prototype "smart" bullets.
  - Use virtual prototypes and simulations to determine the increase in effectiveness over "dumb" bullets and to evaluate the logistic cost savings.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Tactical Technology TT-06	33.221	32.232	42.322	42.073	44.230	41.371	41.371	41.371	Continuing	Continuing

(U) **Mission Description:**

(U) This project focuses on five broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, and high-power laser applications; (b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (c) precision optics components for critical DoD applications; (d) aerospace electronic warfare systems (e.g. coherent spoofers, decoys, jammers); and (e) very high speed aerospace vehicle and enabling technology (Affordable Rapid Response Missile Demonstrator). Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems, and emerging payload delivery concepts.

(U) Compact Lasers: This program will develop compact diode-pumped, solid-state lasers and laser-diode arrays (10x improvement in efficiency) with tens of watts average power output and wavelength tuneability in the mid-infrared spectral regions to provide laser sources for infrared countermeasures against heat-seeking missiles for rotary wing/fixed wing aircraft and sea-borne platforms. Additionally, it will develop ultra broadband and very short pulse solid-state laser technology and ultra high power short pulse lasers. The program will explore a combination of microelectromechanical systems (MEMS) based electro-optic spatial light modulators in combination with very short pulse solid state lasers to provide powerful new capabilities for secure communication up-links (multi-gigabits per second), aberration free 3-dimensional imaging and targeting at very long ranges (> 1000 kilometers). Lastly, innovative design concepts and system integration of MEMS-based spatial light modulators (SLMs), that provide a quantum leap in wavefront control, photonics and high speed electronics, will be explored for an affordable and high value communications, image sensing and targeting system for use well into the 21^{st} century.

(U) High Performance Algorithm Development and Advanced Mathematics for Microstructural Process Control: these programs will identify, develop, and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a wide variety of DoD systems applications. They will look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit the power of large-scale computational resources as they apply to specific problems of interest. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-

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dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems such as adaptive array processing for missile seekers, waveform design for spaceborne sensors and communication applications, virtual integrated prototyping of advanced material processing, efficient high fidelity scattering computations for radar cross sections, and efficient mapping of signal processing kernels onto advanced DoD hardware architectures.

(U) Micro-Launch Vehicle: The Micro-Launch Vehicle will be capable of placing a micro-satellite into low Earth orbit (LEO) on-demand and at an order-of-magnitude lower cost than existing systems. The vehicle will use inherently safe and low-risk hybrid rocket technology combined with unique low-cost manufacturing techniques to achieve its operational and cost objectives. This technology will be readily applicable to both military and commercial launch of micro-sized communication satellites. The program will include a sub-orbital flight demonstration of the upper (third) stage, then a sub-orbital flight demonstration of both second and third stages and culminate with the placement of a micro-satellite into low-earth orbit.

(U) Active Rocket: National agencies have a need for space launch systems that are both cost effective and capable of handling payloads to perform their duties. While improved design tools have resulted in increased rocket reliability and safety, industry and the government continues to use the same design strength margins for error and safety that were used when the design tools were much less accurate. The Active Rocket program will design and develop a virtual prototype and brassboard system to demonstrate technologies that will result in increased safety and reliability and reduced cost for space launch systems. The system will prudently reduce design strength margins and thus increase payload, employ active control techniques to control rocket combustion more accurately than passive techniques and thus increase rocket payloads, and, in near real time, predict, diagnose, manage, and report the health of the space launch system. The Active Rocket program will leverage the advancement in space microelectronics and new materials towards development of smarter, cheaper and more durable space platforms.

(U) Water Rocket: The Water Rocket program will support research and development of a novel concept for space power and propulsion supported by water as a replenishable propellant and fuel. Water is an inexpensive and easily handled propellant. The program will develop and demonstrate thrusters that use either water or its constituents, hydrogen and oxygen. High power thrusters will be developed for rapid maneuvering and high specific impulse thrusters will be developed for greater economy in use of the water propellant. A regenerative fuel cell system will be developed and demonstrated. The regenerative fuel cell will serve two purposes. It will convert the water to hydrogen and oxygen for use in thrusters. It will also generate electricity while converting some of the hydrogen and oxygen back to water, thereby replacing the heavy batteries routinely used in satellites to supply electric power during nighttime. The Water Rocket program will develop technologies and demonstrate that the

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subsystems can be designed and built as space qualified. As a result of this program, future spacecraft will be more easily refueled for extensive maneuvering and changes of orbit to accomplish advanced missions.

(U) Precision Optics: The Precision Optics program developed mathematical design tools and fabrication strategies for conformal sensor windows, cylinders, toroids, and diffractive optical elements. These tools and strategies provide distortion-free imaging with greater than hemispherical field-of-regard and reduced aerodynamic drag for precision strike and integrated bomb damage assessment for next-generation airborne platforms/high-speed missiles.

(U) The Miniature Air-Launched Decoy (MALD) advanced concept technology development (ACTD) program developed and demonstrated a small, inexpensive air-launched decoy system for Suppression of Enemy Air Defenses (SEAD). MALD will be employed to enhance the survivability of friendly aircraft by establishing air superiority through stimulating, diluting and confusing enemy Integrated Air Defense Systems (IADS). Other applications of the miniature air vehicle system to employ other electronic warfare approaches, which include coherent radio frequency (RF) spoofers, and RF jammers. The Air Force has budgeted procurement funding for this effort starting in FY 2001/02.

(U) The Affordable Rapid Response Missile Demonstrator (ARRMD) pursued a highspeed air breathing propulsion system with more than triple the installed specific impulse (ISP) of current rocket power systems.

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 2000 Accomplishments:</u>**

- Compact Lasers. ($ 5.570 Million)
  - Developed system applications concept and preliminary design of spatial light modulators and integrated electronics for Coherent Communications, Imaging and Targeting (CCIT).
  - Performed feasibility studies and concept development of enabling alignment and docking technologies using compact solid state laser technology for advanced space-based systems.

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- Precision Optics. ($ 6.716 Million)
  - Completed assembly and test of conformal optics Stinger missile dome to quantify performance improvements.
  - Demonstrated imagery through Stinger conformal missile dome.

- High Performance Algorithm Development. ($ 8.487 Million)
  - Demonstrated utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
  - Developed advanced mathematical algorithms for high throughput hyperspectral infrared imaging.
  - Validated fast algorithms for electromagnetic scattering at subwavelength scales and off of rough surfaces.
  - Developed codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.

- Advanced Mathematics for Microstructural Process Control. ($ 2.197 Million)
  - Constructed and tested control/optimization codes for sputtering, evaporation and molecular beam epitaxy reactors.
  - Extended level set methodology to complex diffusion processes in thin film processing.

- Miniature Air-Launched Decoy (MALD). ($ 0.535 Million)
  - Continued operational assessment exercises with thirty-two test assets to support transition to Air Force.
  - Continued to investigate ACTD design shortfalls and testing anomalies. Supported redesign efforts to increase reliability.
  - Coordinated transition of the MALD Program to the Air Force for initial quantity buy (150 units).

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 7.326 Million)
  - Conducted booster configuration trade study.
  - Conducted second force and moment test series.
  - Performed design optimization studies.
  - Selected demonstration booster configuration.
  - Conducted structural validation testing.
  - Completed system preliminary design.
  - Continued exploration of supporting technologies for hypersonic missiles.
  - Initiated Phase II activities.

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- Initiated detailed vehicle design.
- Completed flight test plan for first flight articles.

• Advanced Tactical Technology Concepts. ($ 2.390 Million)
- Explored and assessed feasibility of new concepts for high-speed launch of small payloads and autonomous maintenance capabilities, exploiting next generation space-based sensors (e.g. lasers, electro optic, and millimeter wave).

(U) **FY 2001 Plans:**

• Compact Lasers for Coherent Communications, Imaging and Targeting. ($ 1.985 Million)
- Develop breadboard system with high-speed electronics integration.
- Demonstrate greater than 1-kilometer operation for static platform and target.
- Develop very high power short pulse lasers using plasma based pulse compression.

• High Performance Algorithm Development. ($ 9.000 Million)
- Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal-processing algorithm.
- Develop and test algorithms for variable precision filters for adaptive signal processing.
- Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.
- Develop algorithms for predicting and optimizing antenna radiation patterns and scattering, both off of, and through, inhomogeneous materials and deep cavities.
- Develop computationally efficient geometric compression and registration algorithms for topography/imagery databases.

• Advanced Mathematics for Microstructural Process Control. ($ 1.918 Million)
- Validate reduced order model and algorithms for sensing and control of thin film vapor deposition processes.
- Demonstrate advanced molecular dynamics/accelerated molecular dynamics simulation techniques for the growth of multilayer materials.

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- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 17.866 Million)
  - Conduct high mach number wind tunnel testing.
  - Conduct critical design review.
  - Initiate fabrication of missile demonstrators.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Initiate flight weight engine ground demonstrator test hardware fabrication.

- Advanced Tactical Technology Concepts. ($ 1.463 Million)
  - Perform feasibility evaluation studies of emerging advanced tactical technology concepts, including enhanced air vehicle survivability, innovative engines and propulsion techniques, payload delivery methods, and enabling technologies for advanced space systems.

(U) **FY 2002 Plans:**

- Compact Lasers for Coherent Communications, Imaging and Targeting. ($ 7.914 Million)
  - Develop 32x32 unit cell scalable spatial light modulator with integrated electronics.
  - Develop breadboard system with application specific hologram processor, receiver, and short pulse amplifier.
  - Demonstrate horizontal slant-path communication links and aberration free imaging at ranges up to 10 kilometers.
- High Performance Algorithm Development. ($ 10.000 Million)
  - Demonstrate validated, high fidelity, efficient electromagnetic scattering prediction at frequencies up to X-band for cruise missile sized objects with simple boundary conditions (i.e., perfect electrical conductor and impedence boundary condition).
  - Develop and demonstrate feature extraction and three-dimensional imaging capability in passive interferometric sensors.
  - Demonstrate feasibility of designs for quadrature thinning of 2-D conformal arrays which exhibit the same or better beam patterns than conventional arrays and yet use only one-third of the T/R (transmit/receive) modules.

- Advanced Mathematics for Microstructural Process Control. ($ 1.871 Million)
  - Demonstrate tool kit software for optimized design for thin film vapor deposition processes including real time process control strategies.

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- Micro-Launch Vehicle (Mu-LV). ($ 9.537 Million)
  - Design reaction control system (RCS) and guidance, navigation and control (GNC) software.
  - Optimize flight-weight liquid oxygen (LOX) turbopump and heat exchanger design.
  - Ground test third stage with turbopump LOX delivery.

- Active Rocket. ($ 5.000 Million)
  - Conduct cost benefit trade studies on potential Active Rocket technologies.
  - Begin design efforts on a virtual prototype of a space launch system to demonstrate:
    - Reduced structural margins.
    - Active combustion control system.
    - Automated health management.

- Water Rocket. ($ 8.000 Million)
  - Conduct critical technology demonstrations for Water Rocket.
  - Begin detailed subsystem designs in the areas of regenerative fuel cells, fuel storage tanks, and water-based thrusters for Water Rocket.

(U) **FY 2003 Plans:**

- Compact Lasers for Coherent Communication, Imaging and Targeting. ($ 10.000 Million)
  - Develop 1024x1024 spatial light modulator with integrated electronics.
  - Develop prototype system with high speed parallel electronics.
  - Demonstrate ground/mountain communication links and three dimensional coherent imaging with turbulence compensation at ranges greater than 10 kilometers.

- High Performance Algorithm Development. ($ 8.000 Million)
  - Demonstrate efficient, accurate predictive algorithms for electromagnetic scattering from inhomogeneous and anisotropic materials.

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- Demonstrate efficient scattering codes capable of accurate computation of Radar Cross Section for cruise-missile-sized vehicles with realistic material boundary conditions and full complexity components.
- Develop and demonstrate spatio-spectral feature extraction and four-dimensional (three spatial, one spectral) reconstructions in passive interferometric sensors.
- Demonstrate robust beamforming and adaptive array algorithms for quadrature-thinned 2-D conformal arrays exhibiting same or better cancellation of interference than conventional arrays with only one-third of the T/R (transmit/receive) modules and with at least 10x reduction in computational costs.
- Demonstrate feasibility of contrast invariant geometry-based fusion of infrared video frames with digital terrain elevation data and feature data for applications to cruise missile mission planning.

- Micro-Launch Vehicle (Mu-LV). ($ 10.073 Million)
  - Conduct third stage sub-orbital flight.
  - Perform stage separation studies.
  - Ground test first/second stage motor. Integrate reaction control system (RCS) and guidance, navigation and control (GNC).
- Active Rocket. ($ 6.000 Million)
  - Complete design efforts.
  - Construct a scaled brassboard space launch system.
  - Conduct tests and simulations with the brassboard space launch system.

- Water Rocket. ($ 8.000 Million)
  - Complete final designs of Water Rocket technologies and subsystems.
  - Fabricate Water Rocket subsystems and perform ground tests.
  - Perform cost effectiveness analysis of the Water Rocket technologies and subsystems.

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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 2000	FY 2001	FY 2002	FY 2003
Miniature Air-Launched Decoy (MALD), PE 0603750D, Advanced Concept Technology Demonstrations	2.000	3.000	0.000	0.000

(U) **Schedule Profile:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Aeronautics Technology TT-07	40.302	29.131	26.475	32.593	42.450	44.291	47.291	47.291	Continuing	Continuing

(U) **Mission Description:**

(U) Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) are being developed and demonstrated. The capability to accomplish unique military missions as diverse as small unit reconnaissance and surveillance, support of military operations in urban terrain, targeting and tagging high-value targets in denied areas, and, biological-chemical agent detection and characterization, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, power and propulsion, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small-scale actuators. MAFC technologies combine adaptive control strategies, with advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to delay or prevent fluid flow separation. MAFC technologies will be explored for applications such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

(U) The goals of the Advanced Rotorcraft Technology (ART) program are to investigate the merits of various advanced rotorcraft technologies and to conduct technology maturation efforts for select high risk, high payoff technologies. The current ART program consists of the

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following tasks: Task 1 will complete design and fabrication, and perform tests of a full scale split torque helicopter main rotor transmission based on face gear technology; a unique gear grinding process that enables production grinding of aircraft quality face gears. The project will yield a completed 2,828 horsepower demonstrator transmission, and will perform testing of the design's concentric face gear split torque concept, durability improving modifications to gears and smaller subsystem tests. Task 2 will consist of tests and experiments to investigate and mature Variable Diameter Tilt Rotor (VDTR) technology. The tilt rotor concept, as embodied in the V-22 aircraft, attempts to achieve the speed of a turboprop aircraft combined with the vertical takeoff and landing capability of a helicopter. The size of the rotor/propeller in current applications is compromised between that desired for a lifting rotor (large diameter) and that size desired for a thrusting propeller (small diameter). The VDTR concept is an attempt to optimize both the rotor size and the propeller size by including a mechanism that extends and retracts the diameter of the rotating airfoils. Task 3 will create a knowledge base and computer code to analyze the operational merit of advanced rotorcraft technologies such as VDTR, Face Gears, Microadaptive-Flow Control, and Smart Materials.

(U) Concepts for a new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 10.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles, missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas turbine and micro rocket engines to 5-cm scale gas turbine and pulse detonation engines. Engines may be explored at larger scale to prove feasibility. Examples of new mission capabilities may include delivery of very small (200g) satellites to low earth orbit, light weight, long endurance miniature reconnaissance vehicles, and extended range small scale precision munitions. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) The Supersonic Aircraft Noise Mitigation program is directed towards the development of a vehicle capable of long-range missions with sustained supersonic flight with low takeoff noise and mitigated sonic boom. Highly integrated vehicle concepts will be explored to simultaneously meet the cruise range and noise level goals. Advanced airframe technologies will be explored to minimize sonic boom and vehicle drag. High performance propulsion systems will be developed to permit long-range supersonic flight with low takeoff and cruise noise levels.

(U) The goals of the Short Take-Off and Vertical Landing (STOVL) Unmanned Combat Air Vehicles (UCAVs) program are to investigate the merits of various advanced STOVL design concepts and to conduct technology maturation efforts for critical technologies. STOVL design concepts that enable UCAVs to operate from ships at sea and unprepared areas ashore will be developed and critical technologies demonstrated. The capability to accomplish unique military missions as diverse as organic reconnaissance and surveillance, support of military operations in the littoral areas, targeting, tagging, and even destruction of high-value targets in denied areas, will be stressed through an examination of a variety of vehicle

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concepts. The STOVL UCAV program will focus on the technologies and components required to enable flight in the STOVL arena, including flight control, power and propulsion systems, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Ceramic components directly enable high performance propulsion systems and advanced air vehicles. Propulsion system performance is greatly improved by increasing combustion and turbine inlet temperatures. Current propulsion systems are temperature limited because of temperature fatigue limits of conventional metal alloy engine components, particularly in the turbine. Ceramic materials have superior high temperature performance compared to metals. Ceramics applied to key propulsion system components will enable higher temperature operation with an additional benefit of lower weight compared to conventional metal alloy systems. New engine paradigms will be developed that utilize the unique characteristics of ceramic materials.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2000 Accomplishments:</u>

- Micro Air Vehicle (MAV). ($ 7.393 Million)
  - Completed development of flight enabling technologies for micro air vehicles.
  - Completed fabrication, flight-testing and demonstration of multiple fixed-wing and rotary-wing MAV systems.
  - Completed development of MAV compatible power and propulsion subsystems, autonomous navigation and control subsystems, and sensor subsystems.
  - Continued concept of operations evaluation for military use.

- Micro Adaptive Flow Control (MAFC). ($ 8.428 Million)
  - Continued MAFC actuator and controller development. Assessed actuator and control system performance, control authority, bandwidth and power requirements.
  - Integrated open-loop MAFC technology into feasibility demonstrations for selected military applications, including high-work compressors, maneuvering of uninhabited air vehicles, and fixed-and rotary wing air vehicles.

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- Initiated systems studies for new applications of closed-loop MAFC under full scale system conditions for hydrodynamic drag reduction, 40-mm grenade flight control, integrated inlet and compressor flow control, stator vane flow control and STOVL exhaust acoustic control.

• Small Scale Propulsion Systems (SSPS). ($ 4.465 Million)
- Completed concept evaluation of several small-scale propulsion systems, including turbines, rockets and internal combustion designs.
- Began detailed design of selected prototype propulsion systems.

• Advanced Rotorcraft Technology (ART). ($ 3.281 Million)
- Conducted design work on the face gear, split torque Apache transmission.
- Completed the mechanical reliability testing of the variable diameter tilt rotor sliding bearing under various environmental conditions including ice and exposure sand as well as extreme hot and cold ambient temperature conditions.

• Advanced Aeronautic Concepts. ($ 1.735 Million)
- Conducted technology assessments and feasibility testing of advanced aeronautic concepts, including supersonic laminar flow, air-to-air resupply and continuous aerodynamic control surfaces.

• Supersonic Aircraft Noise Mitigation (SS A/C NM). ($ 15.000 Million)
- Developed technologies for long-range supersonic aircraft having low sonic boom and noise signature, range augmentation through low vehicle drag, and advanced propulsion systems.
- Developed highly integrated systems concepts for a supersonic long-range aircraft.

(U) **<u>FY 2001 Plans</u>:**

• Micro Air Vehicle (MAV). ($ 0.646 Million)
- Complete development of basic enabling MAV technologies and subsystems.

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- Micro Adaptive Flow Control (MAFC). ($ 12.903 Million)
  - Initiate fully implemented MAFC technology development and validation tests for scale model of V-22 lift enhancement, high speed inlet mesoflaps, large scale wing model synthetic jet lift control, and delayed retreating blade stall.
  - Complete demonstration of high speed compressor stage with aspiration flow control to give pressure rise of 3.4 across the stage
  - Complete demonstration of biomorphic flapping flight.
  - Initiate the development of closed-loop MAFC technologies toward feasibility demonstrations.

- Small Scale Propulsion Systems (SSPS). ($ 9.925 Million)
  - Complete detailed design for propulsion systems.
  - Complete critical subsystem fabrication and testing.
  - Begin fabrication of full propulsion systems.

- Advanced Rotorcraft Technology (ART). ($ 5.657 Million)
  - Complete design work and begin manufacturing of an AH-64 sized face gear helicopter transmission.
  - Complete reliability testing of extension/retraction and locking mechanisms and complete actuation control unit test for the variable diameter tilt rotor.

(U) **FY 2002 Plans:**

- Micro Adaptive Flow Control (MAFC). ($ 10.414 Million)
  - Continue closed-loop MAFC actuator and controller development. Assess actuator and control system performance, control authority, bandwidth and power requirements.
  - Complete MAFC feasibility demonstrations for selected military applications, including scale model of V-22 lift enhancement, high speed inlet mesoflaps, large scale wing model synthetic jet lift control, and delayed retreating blade stall.
  - Initiate studies to integrate MAFC technologies into full-scale engine and aircraft systems. Initiate demonstration plan, including flight and field tests of integrated MAFC systems.

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- Small Scale Propulsion Systems (SSPS). ($ 9.893 Million)
  - Complete fabrication and testing of propulsion systems.
  - Complete vehicle integration studies.

- Advanced Rotorcraft Technology (ART). ($ 1.000 Million)
  - Complete 200-hour endurance test of face gears and complete design of modified gears, bearings and housing required for phase II.
  - Complete updated retraction mechanism risk reduction test for the variable diameter tilt rotor.

- Short Take-Off and Vertical Landing (STOVL) Unmanned Combat Air Vehicles (UCAV). ($ 3.168 Million)
  - Investigate technologies required for STOVL UCAVs to operate from ships at sea and unprepared areas ashore.
  - Initiate designs for STOVL propulsion systems and concept integration into UCAV vehicles.

- Ceramics for Propulsion Systems (CPS). ($ 2.000 Million)
  - Initiate technology development for advanced ceramic components.
  - Complete systems studies to determine payoff of monolithic ceramics and ceramic matrix composites in propulsion systems.

(U) **FY 2003 Plans:**

- Micro Adaptive Flow Control (MAFC). ($ 8.000 Million)
  - Complete closed-loop MAFC actuator and controller development. Assess actuator and control system performance, control authority, bandwidth and power requirements.
  - Continue application of closed-loop MAFC under full-scale system conditions for hydrodynamic drag reduction, 40-mm grenade flight control, integrated inlet and compressor flow control, stator vane flow control and STOVL exhaust acoustic control.
  - Continue flight and field tests of integrated MAFC systems.

- Advanced Rotorcraft Technology (ART). ($ 1.000 Million)
  - Complete fabrication of bearings, gears, and housing; perform slow-roll, dynamic, and oil-out testing of face gear transmission.

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- Short Take-Off and Vertical Landing (STOVL) Unmanned Combat Air Vehicles (UCAV). ($ 13.593 Million)
  - Develop flight-enabling technologies for STOVL UCAVs.
  - Complete preliminary designs for propulsion systems and critical components.
  - Develop highly integrated systems concepts for a STOVL UCAVs.

- Ceramics for Propulsion Systems (CPS). ($ 10.000 Million)
  - Complete conceptual designs of advanced ceramic-based propulsion systems.
  - Fabricate and test ceramic components in propulsion.
  - Initiate large scale testing of ceramic components in propulsion system environment.

(U) **<u>Other Program Funding Summary Cost</u>:**

- Not Applicable.

(U) **<u>Schedule Profile</u>:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Logistics Technology TT-10	14.993	27.791	23.564	23.800	23.800	24.300	24.300	24.300	Continuing	Continuing

(U) **Mission Description:**

(U) The overarching objective of the Advanced Logistics Technology project is to revolutionize the way the DoD plans, executes, monitors, and dynamically replans logistics support across the entire spectrum of operational environments from day-to-day routine peacetime operations, disaster relief, non-combatant evacuation, peacekeeping, peacemaking, and minor and major contingencies. The project consists of two major programs, the Advanced Logistics Program (ALP) and the UltraLog Program.

(U) The Advanced Logistics Program (ALP) is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts is virtually impossible to accomplish today. The ALP will address these shortcomings and enable this significant capability to be developed. In addition, the program has enormous potential for cost savings through greatly improved management of transportation and logistics assets. ALP will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan, as the situation requires, even while assets are enroute to the theater. The ALP is focusing on the following three areas: 1) development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure.

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(U) The UltraLog program will build on the baseline security, robustness and scalability investigation and analysis during the Advanced Logistics Program and develop and demonstrate advanced military grade measures for security, robustness, and scalability to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare (IW) environments. Using the infrastructure developed by the Advanced Logistics Program, UltraLog will pursue research breakthroughs in four main areas: (1) Security: Investigate information pedigree, white-noise generation, dynamic random routing, agent gateways, dynamic PKI key management, recovery reconstruction protection, dynamic communications and security measures, information rovers, correlation and isolation of compromised agents and other techniques to achieve a secure, trusted system even under directed information warfare attack; (2) Scalability: Investigate assured convergence, automatic dampeners, adaptive configuration, resource pooling/proxy, variable fidelity processes, sliding temporal horizons, ultra-efficient agent negotiations, reactive plan space management and other techniques to achieve a highly scalable and stable system even under very chaotic wartime environments; (3) Robustness: Investigate non-local persistence, fault tolerance and recovery, distributed consistency checking, partial state validation, dynamic communications-aware redundancy, dynamic adaptation, temporal horizons and other techniques to achieve a state of high survivability under frequent and significant failure warfare environments; and (4) Systems Integration and Development: Synergistically combine security, scalability and robustness techniques that will provide the highest level of capability while ensuring the overall functionality of the distributed logistics enterprise is preserved. Though many of the research efforts will be accomplished independently and in parallel, the real challenge will come in the integration synergy of the various techniques to produce the desired systemic effects. Technical and Survivability Red Teams will also be used to evaluate the features and deficiencies of each capability or combination of capabilities, annually. These evaluations will drive the following year's focus, expanding where there is promise and curtailing what has proven ineffective. Each year the evaluation environment will become more complex, the requirements greater, and the evaluation space expanded to eventually create the most brutal information warfare environment possible in an experimental environment.

(U) The Advanced Logistics Technology program supports Joint Vision 2010, US Transportation Command, Defense Logistics Agency, and Service initiatives, and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately transition to other joint initiatives, which include the Defense Logistics Agency's Logistics Research and Development Demonstration (PE0603712S), the Joint Logistics and Joint Theater Logistics Advanced Concept Technology Demonstrations (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System (GCSS).

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Advanced Logistics Program (ALP). ($ 14.993 Million)
  - Developed capability to automatically plan and schedule movements from installation to the theater of operations and integrated the resulting movement plan with operations within the theater. Demonstrated capability for users to visualize multiple facts of the transportation schedule.
  - Developed capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies.
  - Developed capability to automatically notify users when projected completion of an executing task differs from planned timeline.
  - Constructed and conducted a detailed baseline analytical evaluation of the ALP architecture for security, scalability and robustness.
  - Established the development and experimental environments, which included the necessary security considerations and classifications for large-scale experimentation of agent societies under kinetic and information warfare environments.

(U) **FY 2001 Plans:**

- Advanced Logistics Program (ALP). ($ 9.925 Million)
  - Develop capability to automatically build and compare logistics plans in support of four operational courses of action in four hours.
  - Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations.
  - Conduct a pilot test of advanced logistic technology using the Focused Logistics Wargame 2001.
  - Develop plans for conducting follow-on pilot tests.

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- UltraLog. ($ 17.866 Million)
  - Establish the development and experimental environments and the metrics and methods by which the experimentation will be evaluated.
  - Design, develop and evaluate a variety of independent technologies for security, scalability and robustness that demonstrate the potential for extending and enhancing large-scale, distributed agent systems, with special attention to experimentally proving the feasibility of each technique based on the technical and functional requirements.
  - Perform systemic analysis of combinations and layering of developed technologies for overall effectiveness under varying experimental and environmental conditions.

(U) **FY 2002 Plans:**

- UltraLog. ($ 23.564 Million)
  - Develop, integrate and evaluate a synergistic collection of technologies providing dynamic information security, agent architecture survivability in an information warfare environment and sustained wartime logistics operations.
  - Establish instrumented and configurable wartime operating environment with chaotic real time systems, communications, and event failures.
  - Conduct review by external, independent evaluation teams (red teams) of both the concept of operations and technical designs of the various system components to identify deficiencies and recommend improvements. Incorporate recommendations and mitigating approaches to ongoing development effort.

(U) **FY 2003 Plans:**

- UltraLog. ($ 23.800 Million)
  - Develop, integrate and evaluate a refined portfolio of technologies, integrated and layered, to provide effective security, scalability and robustness under a moderately chaotic wartime and information warfare environment.
  - Conduct a further review by external, independent evaluation teams (red teams) of both the concept of operations and technical designs of the various system components to identify deficiencies and recommend improvements. Incorporate recommendations and mitigating approaches to ongoing development effort.
  - Migrate maturing concepts and technologies to transition agencies and services using ALP agent technologies.

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– Demonstrate the survivability of the evaluation system under harsh, chaotic conditions similar to that of a Major Regional Contingency supported by directed adversary information warfare attack.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Joint Logistics ACTDs TT-11	9.390	9.925	9.893	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Joint Logistics project is composed of two Advanced Concept Technology Demonstrations (ACTDs) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Global Combat Support System (GCSS). The initial Joint Logistics ACTD addressed Commander-in-Chief (CINC) and Service requirements to develop JDST capability in the areas of Force Capability Assessment; Logistics Support Concept Generation and Evaluation; Distribution, Materiel Management, Maintenance Analysis; and Visualization. The follow-on ACTD, the Joint Theater Logistics ACTD (JTL ACTD) integrates and expands those and other capabilities to provide real-time management and analysis tools for logistics and operations interoperability. Tools developed in this second ACTD are called Joint Theater Logistics Decision Support Tools (JTLDSTs) to distinguish them from the tools developed in the original ACTD and to emphasize the focus upon forces associated with a Joint Task Force in a theater of operations. These tools will provide warfighters and logisticians with the abilities to: assess support force capabilities to perform mission tasks; develop and evaluate logistics operational support plans; monitor logistics operations; and, react to deviations from projected support. JTL tools will provide the fusion and correlation of plans and information for critical components of theater support, sustainment, and transportation systems providing effective management, analysis, and situational awareness to the logistics commanders. JTL capabilities will include real-time interoperability between logistics and operations during all phases of planning and execution. Key data sources include Joint Total Asset Visibility, Joint Personnel Asset Visibility, the Global Transportation Network, the Joint Operational Planning and Execution System, and the Global Status of Readiness and Training System. The program concludes after FY 2002.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Joint Logistics ACTD. ($ 4.695 Million)
  - Expanded development of Joint Decision Support Tools (JDSTs) to compare planned logistics unit support capabilities with actual capabilities at specific nodes over time.
  - Developed the capability to generate a below-the-line logistics force structure based upon the operational course of action and demonstrated the capability to provide a qualitative force capability assessment of the force structure.

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- Exercised and demonstrated advanced JDST capabilities in an expanded joint warfighting exercise.
- Transitioned proven JDST capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

• Joint Theater Logistics (JTL) ACTD. ($ 4.695 Million)
- Began development of Joint Theater Logistics Decision Support Tools (JTLDSTs)
- Started development of computer-assisted capabilities to evaluate operational and logistics tasks.
- Initialized capability to calculate support unit requirements and sustainment and identified matching sources to meet mission requirements.
- Incorporated logistics support capabilities and operational concepts into a single integrated view.
- Prepared to demonstrate JTL capabilities in a joint warfighting exercise.

(U) **FY 2001 Plans:**

• Joint Logistics ACTD. ($ 0.993 Million)
- Transition Joint Decision Support Tools (JDST) capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

• Joint Theater Logistics (JTL) ACTD. ($ 8.932 Million)
- Expand JTLDST capability to integrate in-theater distribution support planning and infrastructure assessment, and to generate and compare alternative logistics support force concepts to support multiple operational courses of action. Track the execution of sourcing and sustainment from closure through dissemination throughout the theater.
- Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistic activity for select support items by location, provider, and intended consumer.
- Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. Develop a real-time in-theater management capability for critical resources including fuel and munitions, which integrates execution of logistics support plans with logistics and operational data feeds.

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- Develop the capability to forecast the impact of deviations and alternative support concepts upon future operations.
- Demonstrate multi-echelon interoperability and in-theater management capabilities in a joint warfighting exercise.

(U) **FY 2002 Plans:**

• Joint Theater Logistics (JTL) ACTD. ($ 9.893 Million)
- Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistic activity for select support items by location, provider, and intended consumer.
- Provide the warfighter with near real time operations and logistics collaborative capabilities to support planning and execution.
- Incorporate technologies that will track planned versus actual movements and assess logistics readiness, selected weapons systems, and classes of supply.
- Develop and demonstrate a watchboard capability to track and report operational and logistics status of current operations through a web-based framework.
- Provide interactive models for requirements, availability and costs.
- Integrate watchboard and common operational picture views to provide logistics overlays for the warfighter.
- Demonstrate multi-echelon interoperability and in-theater management capabilities in a joint warfighting exercise.

(U) **FY 2003 Plans:**

• Not Applicable.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	37.218	31.761	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Integrated Command and Control Technology IC-03	37.218	31.761	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high-resolution images. This project completes in FY 2001.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- High Definition Systems. ($ 18.546 Million)
  - Developed flexible, rugged displays based on organic electroluminescence and zero-power reflective technology.
  - Developed active matrix backplanes on flexible substrates for high performance/low power rugged displays.
  - Developed enhanced maturing technologies (organic electroluminescence, field emission and flexible field substrates) to performance capabilities required for DoD applications.
  - Demonstrated/inserted display technology into DoD systems to evaluate display technology.

- Flat Panel Displays. ($ 7.000 Million)
  - Continued Flat Panel Display manufacturing equipment and materials.

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- Flexible Emissive Displays. ($ 11.672 Million)
  - Developed higher temperature plastic substrates compatible with display manufacturing.
  - Developed light emitting materials.
  - Demonstrated emissive monochrome display.

(U) **FY 2001 Plans:**

- Flexible Emissive Displays. ($ 12.000 Million)
  - Develop reduced water and oxygen substrate permeability.
  - Develop active matrix backplane transistors.

- High Definition Systems. ($ 19.761 Million)
  - Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. Integrate Field Emission and Phosphor Display Technologies.
  - Evaluate new display concepts for large, high-resolution displays.
  - Demonstrate/insert display technology into DoD systems for display evaluation.

(U) **FY 2002 Plans:**

- Not Applicable.

(U) **FY 2003 Plans:**

- Not Applicable.

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(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	38.126	31.761	0.000	0.000
Current Budget	37.218	31.761	0.000	0.000

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects minor repricing and SBIR reprogramming.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	238.455	249.812	271.254	265.275	270.571	288.594	300.594	305.594	Continuing	Continuing
Materials Processing Technology MPT-01	126.014	130.759	150.031	152.472	152.554	153.395	155.395	155.395	Continuing	Continuing
Microelectronic Device Technologies MPT-02	85.238	96.783	66.229	54.858	60.215	70.556	75.556	75.556	Continuing	Continuing
Cryogenic Electronics MPT-06	27.203	22.270	14.994	7.945	7.802	9.643	9.643	9.643	Continuing	Continuing
Beyond Silicon MPT-08	0.000	0.000	40.000	50.000	50.000	55.000	60.000	65.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-01) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems as well as to increase human performance. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, development of bio-interface materials and methods, energy harvesting concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials

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and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD applications (sensor, robotic, etc.).

(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology. A major initiative to explore the feasibility, design and development of information technology devices and systems utilizing non-silicon based materials and techniques is planned for initiation in FY 2001 and transfers to a separate project (MPT-08) in FY 2002.

(U) In the Cryogenic Electronics project (MPT-06), thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid-state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

(U) The Beyond Silicon project (MPT-08) will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches to electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non-silicon based materials technologies, to achieve low cost, reliable, fast, and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities; from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices.

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(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	242.267	249.812	230.267	215.275
Current Budget	238.455	249.812	271.254	265.275

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects program repricings and SBIR reprogramming.
FY 2002-03 Increases reflect new project (MPT-08) for Beyond Silicon.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Materials Processing Technology MPT-01	126.014	130.759	150.031	152.472	152.554	153.395	155.395	155.395	Continuing	Continuing

(U) **Mission Description:**

(U) The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems.

(U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, amorphous and multi-functional materials for lowering the weight and increasing the performance of aircraft, ground vehicles, and spacecraft structures. Approaches are also being developed for reducing the risk of using new materials in defense acquisitions. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters, and submarines as well as to increase human performance. "Intrinsically smart" materials that provide self-diagnosis and/or self-repair will be developed as well.

(U) Another major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators, and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored. Finally, engineered materials (meta materials) are being developed that provide improvements in electromagnetic behavior across the complete array of defense applications.

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(U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors and mesocoolers for the individual soldier. Technology for the mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of both active and passive components, significantly reducing the size, weight and cost of integrated electronics functions (circuits, batteries, antennae, etc.).

(U) New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power for soldiers and sensors from the environment. These efforts will contribute to the design and fabrication of biohybrid devices. Structure and function emulated from biological systems will result in new biomimetic systems that capture unique locomotion and sensing schemes.

(U) Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials, and hybrid bioelectronics that electronically control biological organisms or use biological intelligence for smart materials. The interface between biologically inspired devices, electronics and information processing will also be explored.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Structural Materials and Devices. ($ 18.000 Million)
  - Integrated material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
  - Developed analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in Defense acquisitions.
  - Investigated concepts for the use of multifunctional materials in Defense applications (e.g., blast protection, thermal control) based on successes in ultra-lightweight metals and other structural materials programs.
  - Developed approaches for rapid design, optimization and assembly of small structures based upon solid freeform and rapid prototyping technologies.

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- Mesoscopic Structures and Devices. ($ 8.774 Million)
  - Demonstrated the operation of a mesoscopic pump array with flow rates of several liters/min. in one cubic inch.
  - Built and tested an individual integrated mesoscopic cooler.
  - Demonstrated a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
  - Demonstrated the ability to directly write active and passive electronic materials and components at the mesoscale.

- Smart Materials and Actuators. ($ 25.000 Million)
  - Demonstrated improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Developed a "smart skin" for the reduction of self-noise and radiated noise in torpedoes.
  - Explored novel actuator schemes for enhancing the performance of soldiers or devices.
  - Demonstrated techniques to grow large (>3 cm) single crystals of relaxor piezoelectrics.
  - Demonstrated the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.

- Functional Materials and Devices. ($ 43.904 Million)
  - Demonstrated very fast (<20 nsec access time), high density, radiation hardened magnetic memory circuits utilizing both giant magneto-resistance (GMR) multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrated very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrated permanent magnet materials with 50 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 500°C.
  - Demonstrated a loss tangent less than 0.002 in hybrid ferroelectric/ferrite (meta-material) devices.
  - Demonstrated a broadband 360-degree phase shifter with very low loss for antenna feed applications.
  - Demonstrated polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrated green light-emitting diodes (LEDs) fabricated from electroactive polymers with a half-life >5,000 hours; demonstrated blue and red LEDs with >1,000 hours half-life.
  - Selected appropriate polymeric materials with electronic characteristics for field-effect transistor (FET) development.

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- Demonstrated the growth of AlGaSb-InAs thin-films on GaAs substrates using the lateral epitaxial overgrowth technique.
- Demonstrated lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain-absorbing layers.

• Bioinspired Materials and Devices. ($ 2.400 Million)
- Explored sensormotory and navigational control schemes for biological systems through microelectronic interfaces.
- Evaluated chemical, visual and acoustic cues used by biological systems for controlled locomotion, behavior and distribution.

• Advanced Energy Technologies. ($ 15.436 Million)
- Demonstrated and field tested compact portable power systems in soldier applications.
- Developed high efficiency direct thermal to electric energy conversion.
- Demonstrated (in the laboratory) power generation from the environment capable of operating unattended ground sensors.
- Investigated novel concepts for small-scale, near ambient temperature, chemical power generation.

• Materials in Sensors. ($ 9.500 Million)
- Continued work in materials and processing, including investigation of novel polymer and inorganic sensor and sensor protection schemes.

• Biodegradable Plastics. ($ 1.000 Million)
- Initiated an effort to examine biodegradable plastics for Defense applications.

• Strategic Material Manufacturing. ($ 2.000 Million)
- Continued the effort to develop new manufacturing approaches for cutting tools used for Defense strategic materials.

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(U) **FY 2001 Plans:**

- Structural Materials and Devices. ($ 21.200 Million)
  - Demonstrate ultra-lightweight armor with 100 percent improvement over current materials and begin transition of manufacturing/design capabilities to the Army.
  - Demonstrate the use of multifunctional materials to provide significant improvement in the capabilities of defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, power) to load bearing structures.
  - Continue the optimization of analytical, experimental and simulation technologies for predicting the properties of advanced polycrystalline, nanocrystalline and amorphous materials.
  - Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.

- Mesoscopic Structures and Devices. ($ 14.200 Million)
  - Demonstrate initial, one-dimensional mesoscopic gyroscope operation that has drift rates $<1.0°$/hr.
  - Demonstrate fully functional integrated mesoscopic coolers that exhibit a coefficient of performance >3.
  - Demonstrate that direct-write mesoscale active and passive components have functionality close to discrete surface mount components.
  - Demonstrate the ability to direct-write mesoscale passive components (resistors, capacitors) and antennas on conformal surfaces.
  - Explore energetic machines and devices that aid the soldier in urban terrain.

- Smart Materials and Actuators. ($ 25.800 Million)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to a conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test of a rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Explore techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
  - Develop approaches for integrating actuators, power systems and control methods to affect lightweight, energy efficient actuators for enhancing the performance of soldiers or devices.

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  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in an advanced Navy sonar transducer.

- Functional Materials and Devices. ($ 44.212 Million)
  - Demonstrate a prototype, very high effective density (>16 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance (GMR) or spin-dependent tunneling utilizing very low power and low voltage (<2.5 volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100 times cheaper than conventional technology.
  - Explore applications of meta-materials for advanced electromagnetic devices (e.g., antennas).
  - Demonstrate advantages of polymer based actuators in specific Defense applications (e.g., robotics, sonar).
  - Demonstrate the use of electroactive polymers as thin-film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.
  - Fabricate a preamplifier for a millimeter wave radar front end with a 4-dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.

- Bioinspired Materials and Devices. ($ 5.100 Million)
  - Identify candidates for advanced sensor systems that incorporate biologically inspired concepts including self-calibration, self-healing, variable temperature operation, functional responsiveness and mobility.
  - Construct prototype microelectronic interfaces for control of biological systems.

- Advanced Energy Technologies. ($ 15.247 Million)
  - Demonstrate energy harvesting from the environment for unattended sensor and soldier applications.
  - Demonstrate (in the laboratory) high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop specific approaches for small, chemical power generation that operates at near ambient temperatures.
  - Investigate novel ultra-high energy density power source concepts.

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- Bio:Info:Physical Systems Interface. ($ 5.000 Million)
  - Create new families of catalysts and pathways for synthesizing compounds and materials biomimetically.
  - Explore new architectural components and assembling principles of biological systems; develop new artificial matrices and assembling processes.
  - Develop new materials and matrices for sensing, actuation and computation via biologically inspired routes to material synthesis.

(U) **FY 2002 Plans:**

- Structural Materials and Devices. ($ 27.500 Million)
  - Full demonstration of ultra-lightweight armor materials in a system with 100 percent improvement over currently fielded systems and complete transition to Army.
  - Identify models and mathematical techniques for capturing the physics of failure and behavior prediction in materials suitable for providing information on the degree of in-situ damage accumulation.
  - Demonstrate solutions to critical technical issues for the accelerated insertion of materials, quantifying potential payoff (time and resources) of each. Begin the integration of these technologies into a methodology that will allow designers to cut the insertion time of new materials by over 50 percent.
  - Quantify the performance of multifunctional structures that combine structure with additional functions, significantly reducing the parasitic weight of the structure in defense systems. Specific functions to be demonstrated include: self-healing, power generation, and self-sensing.
  - Develop and verify models that predict bulk amorphous metal formation; describe the deformation behavior of structural amorphous metals. Use these models to produce bulk amorphous materials with superior properties as compared to crystalline materials, including increased fracture toughness and high strain rate behavior.

- Mesoscopic Structures and Devices. ($ 16.530 Million)
  - Demonstrate the ability to "dial-in" any passive component with at least 5 percent tolerances with direct-write electronics manufacturing tool.
  - Fabricate direct-write batteries on complex geometries.
  - Demonstrate two-dimensional patterning of two cell types with the associated micro-electrode array using direct-write.

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- Fabricate high efficiency direct-write antennae on low-temperature substrates.
- Investigate concepts for highly power-dense, portable mesoscale machines and devices that aid the soldier in urban terrain.
- Demonstrate proof of concept of devices for obtaining water from air or other non-traditional sources in quantities sufficient to significantly reduce water transportation logistics burden.
- Demonstrate the ability to desalt seawater with low-energy, e.g., 75 percent energy recovery.

• Smart Materials and Actuators. ($ 31.700 Million)
- Demonstrate the utility of smart materials and adaptive structures in military platforms.
- Develop concepts that exploit smart materials to create new high power actuators for a variety of military platforms.
- Demonstrate energy efficient electronics for smart actuator systems.
- Demonstrate integrated power and actuation systems that exploit energy dense fuels.
- Develop models that describe the dynamic performance required from actuators to augmented soldiers in a variety of mission scenarios.
- Explore systems architectures for enhancing soldier physical performance including lower extremities for locomotion augmentation and upper extremities for strength augmentation.
- Demonstrate pilot production technology for piezocrystals in quantities and at cost suitable for prototype devices.
- Demonstrate, on laboratory scale, targeted Naval sonar device/system performance using piezocrystals.

• Functional Materials and Devices. ($ 49.500 Million)
- Demonstrate prototype frequency and phase agile antennas and filters for transition to radar and communication systems.
- Demonstrate embedded magnetoresistive non-volatile radiation hard memory for reconfigurable processors.
- Demonstrate and quantify the sensor capability of electroactive polymers in Defense applications.
- Demonstrate use of electroactive polymers in color displays, including flat panel and real 3D displays.
- Integrate a spin transport device with a high-speed conventional circuit to add significant new functionality.
- Demonstrate a spin-based quantum memory with > 5 qubits.
- Identify, develop and optimize new synthesis and processing schemes for fabricating engineered meta materials that will demonstrate electromagnetic performance significantly above those available from natural materials, including “left-handed” materials and enhanced energy product permanent magnets.

- Develop processing approaches for low-cost manufacturing of high-performance printed optics (e.g., gradient index lenses).
- Model rectification response of non-linearly loaded artificial molecules.

• Bioinspired Materials and Devices. ($ 6.795 Million)
- Demonstrate new capabilities in functionalizing magnetic nanoparticles for integration with biological hosts.
- Evaluate efficiency of biomolecular motors that utilize biological energy sources.
- Determine optimal integration of biomolecular motors into nanoscale or microscale devices.
- Demonstrate coordinated leg function in integrated land platforms that utilize biomimetic principles of locomotion and actuation.
- Demonstrate biomimetic sensory prototypes that collect electromagnetic, olfactory and visual inputs.

• Advanced Energy Technologies. ($ 18.006 Million)
- Fully integrate and demonstrate energy harvesting technologies with military applications.
- Fabricate and test new direct methanol membrane electrode assemblies based on materials breakthroughs in membranes and catalysts.
- Design a second-generation portable direct methanol fuel cell with 50 percent higher performance than the first generation.
- Develop novel hydrogen storage and generation materials that exceed existing materials performance by a factor of ten.
- Demonstrate direct electrochemical oxidation of hydrocarbon fuels at moderate temperatures in a single cell solid oxide fuel cell suitable for a hand-held system.
- Develop concepts for hand-held hydrocarbon-fueled portable power sources in the 20-watt power range for advanced soldier systems.

(U) **FY 2003 Plans:**

• Structural Materials and Devices. ($ 28.700 Million)
- Validate, using existing designer data, that the accelerated insertion methodology will cut the insertion time of a new material by over 50 percent. Initiate the application of the methodology to new materials that, if inserted, will significantly improve Defense systems.
- Fabricate prototype systems that demonstrate the value of multifunctional materials to Defense applications. Demonstrate the use of a multifunctional material as structure plus battery for a micro air vehicle.
- Demonstrate fabrication (forming, joining, etc.) technologies that yield bulk amorphous metals suitable for Defense applications, especially those that require high fracture toughness, even at high strain rates.

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- Quantify the impact of using bulk amorphous materials in construction of land vehicles and naval vessels.
- Integrate models and sensor data into a system for providing current state awareness and structural performance prediction for Defense systems.
- Demonstrate the use of flight information to predict life and failure of critical structural components.

• Mesoscopic Structures and Devices. ($ 15.969 Million)
- Demonstrate the ability to direct-write semiconductor solar cells on low-temperature substrates.
- Demonstrate the ability to direct-write robust embedded sensor systems with the physical structure along with appropriate encapsulation.
- Fabricate, using direct-write approaches, a three-dimensional pattern of two cell types in three-dimensions to mimic endothelial cells and smooth muscle cells.
- Demonstrate mesoscale energetic devices that create mechanical energy efficiently from chemical fuel sources utilizing precision fluidic controls, enabled by smart materials and MEMS.
- Demonstrate prototype devices to extract water from air capable of generating 2 gallons/day.
- Demonstrate technologies to desalt seawater that have a figure of merit 60x better than state-of-the-art reverse osmosis.

• Smart Materials and Actuators. ($ 34.870 Million)
- Develop novel fluidic and mechanical systems to transmit energy from driver smart materials.
- Using experimentally verified models, simulate applications to military platforms.
- Demonstrate man-machine interfaces that generate command signals and actuation from human physiological response.
- Demonstrate man-wearable, powered actuation systems suitable for integration with the soldier.
- Demonstrate an integrated, powered system for augmenting the locomotion and strength of soldiers using precisely controlled actuators and haptic interfaces.
- Demonstrate distributed sensing system capable of monitoring the movements of soldiers.
- Develop control strategies that will link powered actuation to a soldier's movements.
- Demonstrate, on field scale, targeted Naval sonar device/system performance using piezocrystals.

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- Functional Materials and Devices. ($ 49.533 Million)
  - Demonstrate bulk meta materials with exchange biased permanent magnets with energy product > 60 megagausoersteds at room temperature.
  - Demonstrate novel properties of "left-handed" materials (e.g., negative Doppler shift).
  - Demonstrate meta material advantage in developing effective media with high permeability and low loss at microwave frequencies.
  - Demonstrate the ability of an electroactive polymer to perform muscle-like sensing and actuation in Defense robotic applications.
  - Demonstrate electronically excited spin-coherent devices for high-speed digital circuits.
  - Demonstrate a scaleable, spin-based implementation for quantum logic gates.
  - Demonstrate performance of printed optics suitable for defense sensor applications (visible and/or infrared).
  - Demonstrate rectification of microwave signal using metamaterial rectenna.

- Bioinspired Materials and Devices. ($ 5.800 Million)
  - Demonstrate the advantage of a bio-magnetics interface in achieving novel and improved biological and chemical sensing capabilities.
  - Examine integration of biological motor elements (motile cells or tissues) into working machines and determine energy efficiency and power output.
  - Explore biomimetic sensory fusion processing.
  - Integrate biomimetic sensors into mobile platforms.

- Advanced Energy Technologies. ($ 17.600 Million)
  - Demonstrate a portable direct methanol fuel cell system with 50 percent higher performance than the first generation.
  - Fabricate hand-held hydrogen storage/generation systems capable of delivering 10 percent by weight hydrogen storage at the system level.
  - Fabricate and test components for hand-held direct hydrocarbon energy conversion devices.
  - Demonstrate a 20-watt breadboard hydrocarbon-fueled power system.
  - Demonstrate a 40-watt solid oxide fuel cell stack with internal reforming of hydrocarbon fuel.
  - Design and fabricate 20-watt hand-held direct hydrocarbon energy conversion devices for advanced soldier systems.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Microelectronic Device Technologies MPT-02	85.238	96.783	66.229	54.858	60.215	70.556	75.556	75.556	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics, and infrared devices. Areas of emphasis include high performance Analog-to-Digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, photonics technologies, high temperature electronic devices, and high power electronics. In addition, this project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities.

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. The Beyond Silicon initiative will explore alternatives to silicon based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems, and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum computing, new circuit

(U) The Beyond Silicon initiative will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches to electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non-silicon based materials technologies, to achieve low cost, reliable, fast, and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities; from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices. Given agency emphasis in this area the effort will be funded in a new project, MPT-08, within this program element in FY 2002 and beyond.

(U) The Reconfigurable Aperture (RECAP) program satisfies future military and commercial needs for high capacity communication and sensors by applying developments in micro-electromechanical (MEM) devices and structures to build a new generation of broadband antennas that

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can be electronically reconfigured. Techniques being developed include artificial magnetic conductors, RF MEM switches, Photonic Band Gap ground planes, high-density multi-layer interconnects, and fragmented antennas.

(U) Included within this project is a new initiative starting in fiscal 2002 – Optical Signal Processing of Military RF Waveforms. This program aims to develop photonic components capable of meeting RF signal processing requirements of military platforms.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Reconfigurable Aperture (RECAP). ($ 10.727 Million)
  - Completed technology investigation, preliminary design and limited breadboarding.
  - Distributed Picasso modeling beta code to RECAP contractors to initiate user interaction and obtain requirements.
  - Analyzed, modeled, and measured key technologies such as MEM switches, multi-layer substrates, and configurable radiators.
  - Completed early design of radiating elements and ground plane configurations.
  - Identified an 8:1 fragmented ground plane pattern and a number of potential radiating elements to meet decade bandwidth requirements.
  - Completed Ultra thin lightweight designs of low frequency ground planes and progressed in material testing.

- Digital Receiver Technology. ($ 3.887 Million)
  - Demonstrated a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) with potential for multiple military applications.

- High Powered Solid State Electronics. ($ 2.934 Million)
  - Demonstrated high-current density (>100 A/cm^2) 2500-V class switch from silicon carbide (SiC); demonstrated 2500-V rectifier diode from gallium-nitride (GaN).

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- Sonoelectronics. ($ 6.561 Million)
  - Completed sonoelectronic camera prototype fabrication; carried out laboratory characterization and test-tank evaluation.
  - Demonstrated the lab-proven imager in a very-shallow-water (VSW) field setting.
- Acoustic Micro-Sensors. ($ 2.555 Million)
  - Initiated air-coupled acoustic micro sensor project to demonstrate chip-scale sensor system capable to locate, track, and identify a sound source or a voice in a noisy environment.
- HERETIC. ($ 9.438 Million)
  - Completed integration of Heterostructure Integrated Thermoelectronic (HIT) device arrays with bias and control circuitry on GaAs substrates; completed integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates.
- Advanced Microelectronics (AME). ($ 9.444 Million)
  - Demonstrated circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap.
- VLSI Photonics. ($ 18.545 Million)
  - Developed VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; developed system-level CAD tools.
- Materials Integration on Silicon. ($ 10.524 Million)
  - Initiated an integration program that develops a tool kit of materials and processes for integration of multiple materials onto a single silicon substrate.
- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 8.682 Million)
  - Initiated program to begin a major development in photonics, using both wavelengths – wavelength optics – as well as spatial attributes of light – bulk optics.

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- 3-D Microelectronics. ($ 1.941 Million)
  - Continued development of key technologies behind a packaging concept that uses a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics.

(U) **<u>FY 2001 Plans:</u>**

- Reconfigurable Aperture (RECAP). ($ 16.097 Million)
  - Demonstrate fabrication and reconfigurability of components.
  - Construct fragmented antenna elements, zero phase ground plane, switchable elements, and polyimide materials for low cost component fabrication.
  - Continue successful core technologies and initiate contracts for integrated system application demonstrations concentrating on battlefield communications through low profile satellite communications and wearable low frequency communication antennas, and space/air/surface/submarine-based ELINT, SIGINT and radar systems.

- Digital Receiver Technology. ($ 4.000 Million)
  - Develop 16 Effective bit, 100 MHz bandwidth A/D converter.

- Acoustic Micro-Sensors. ($ 5.953 Million)
  - Demonstrate MEMs-based 3-D acoustic transducers and/or transducer arrays with superior sensitivity, signal-to-noise ratio, and bandwidth that is current state-of-the-practice.

- HERETIC. ($ 7.940 Million)
  - Demonstrate HIT devices on GaAs having better specific heat-removal capacity as the best commercial-off-the-shelf TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having much better heat-removal capacity as the best convective air or liquid cooling systems.

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- VLSI Photonics. ($ 7.940 Million)
  - Demonstrate Synthetic Aperture Radar (SAR) processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection.

- Material Integration on Silicon. ($ 8.934 Million)
  - Continue integration of new material and processes into a single silicon substrate that will drive system performance. Demonstrate logic circuits and power amplifiers on silicon substrates.

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 10.919 Million)
  - Continue component development, integration, algorithms, architectures and sub-system functionality demonstrations.
  - Demonstrate emitters and detectors in the spectral band 350-500 nm.

- Beyond Silicon. ($ 35.000 Million)
  - Hyperscale Electronics and Antimonide Based Compound Semiconductors.
    - Development of design and fabrication of low-cost, reliable computational devices and systems in non-silicon substrates; development of printable circuits, and programming methodologies to obtain desired system behavior from unreliable devices.
    - Investigate computational mechanisms in biological substrates, and the interface with other substrates to obtain novel sensing and control mechanisms.
    - Investigate the application of photonic interconnects for on-chip information communication.
    - Demonstrate non-silicon based transistors technologies based on low bandgap materials capable of multi-gigahertz operation at bias voltages < 1 volt.
    - Demonstrate nanostructured materials for quantum based electronic and optoelectronic device applications.
    - Demonstrate an all semiconductor spin filter for injection of spin-polarized electrons at room temperature.
    - Demonstrate a three terminal spin dependent resonant tunneling device operating at several hundred Ghz.
  - Beyond Silicon - Polymorphous Computing Architecture (PCA).
    - Initiate Polymorphous Computing Architecture (PCA) research efforts.
    - Identify and select DoD reactive in-mission and multi-mission applications of interest.

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  - -- Develop PCA hardware abstraction models and stable hardware interfaces.
  - -- Identify stable programming models.
- Beyond Silicon - Quantum Information Science and Technology.
  - -- Investigate techniques for building reliable systems out of devices subject to failures and decoherence, via efficient fault tolerant mechanisms.
  - -- Initiate investigation of new problem classes, beyond factorization and unsorted search, which are solvable with dramatic efficiency on a quantum computer.
  - -- Initiate theory and algorithm research for secure quantum communication; investigate techniques amenable for implementation in existing fiber plant.

(U) **FY 2002 Plans:**

• Acoustic Microsensors. ($ 4.947 Million))
- Integrate MEMs-based 3-D acoustic transducer array with read-out electronics.
- Demonstrate acoustic microsystem for remote detection and tracking of voices or sound sources in noisy outdoor environments.

• Materials Integration. ($ 7.914 Million)
- Complete technology development and demonstrations.
- Demonstrate heterogenous fabrication processes and technologies for integrating disparate semiconductor devices and materials.
- Complete fabrication of composite microcircuits that demonstrate advanced capabilities through the incorporation of devices from multiple materials.

• Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 11.871 Million)
- Develop micro-machined optical elements for spectral bands 300 to 500 nm and to 3 to 15 microns.
- Initiate integration of the passive elements into beam conditioners.

• Digital Receiver Technology. ($ 1.500 Million)
- Demonstrate analog/digital converters with 200 megasamples/second and 16 bits resolution.

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- Reconfigurable Aperture (RECAP). ($ 8.903 Million)
  - Integrate and assemble component technologies into subarrays.
  - Conduct demonstrations of military applications with user participation.
  - Develop and demonstrate low cost fabrication process to support technology transition.

- Optical Signal Processing of Military RF Waveforms. ($ 31.094 Million)
  - Perfom analysis of analog signal characteristics of military RF systems.
  - Create, model and simulate new photonic-based optical signal processing techniques of ultra-high bandwidth analog signals.
  - Evaluate anticipated system performance improvements due to novel signal processing algorithms and determine the resulting photonic component performance requirements.
  - Test signal processing techniques of analog signals.
  - Evaluate signal processing algorithms.
  - Evaluate photonic component performance requirements.

(U) **FY 2003 Plans:**

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 9.000 Million)
  - Demonstrate integration with packaging module.
  - Demonstrate module in a testbed for bio-chemical sensing and spectral imaging.
  - Transition technology to DoD hypospectral/imaging programs and systems.

- Optical Signal Processing of Military RF Waveforms. ($ 45.858 Million)
  - Design, fabricate and test individual photonic components capable of meeting RF signal processing requirements.
  - Determine the most promising approaches for development of integrated, chip-scale components using new materials and processing technology.
  - Determine interface requirements.
  - Evaluate the suitability of the new components for use in prototype modules.

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- Down-select to the most promising approaches and begin prototype module assembly.
- Construct testbeds capable of fully characterizing the photonic-based RF signal processing components.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Cryogenic Electronics MPT-06	27.203	22.270	14.994	7.945	7.802	9.643	9.643	9.643	Continuing	Continuing

(U) **Mission Description:**

(U) Thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include detection and geolocation of targets of high interest based upon low-level characteristic emissions and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Cryogenic Technologies. ($ 22.670 Million)
  - Developed devices and components, based upon superconducting and other electromagnetic materials that in a cryogenic environment would provide a 5-10X-range improvement over conventional means for detection of low-level signals.
  - Completed adaptation of cryocoolers in microelectronics packages for communications transceivers.
  - Expanded efforts in mixed-mode electronics technology development to include tunable high temperature superconducting filters that preserve high-Q, with 10% tunability.

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- Thermoelectric Materials and Devices. ($ 4.533 Million)
  - Demonstrated thermoelectric cooling materials that can achieve 100°C cooling in two stages or less.
  - Demonstrated a thermoelectric converter with a factor of two improvement in power generation per unit size.

(U) **FY 2001 Plans:**

- Totally Agile Sensor Systems (TASS). ($ 22.270 Million)
  - Fabricate a cryogenic module, operating as a front-end pre-selector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/pre-selector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.

(U) **FY 2002 Plans:**

- Totally Agile Sensor Systems (TASS). ($ 14.994 Million)
  - Incorporate agile front-end pre-selector modules on aircraft and ships, utilizing tunable high-Q HTS filters.
  - Demonstrate totally agile sensor systems with 10X SIGINT and COMINT capability.
  - Fabricate Thermoelectric (TE) modules that can be integrated with receiver front ends to provide cooling and/or thermal management as required for enhanced performance.

(U) **FY 2003 Plans:**

- Totally Agile Sensor Systems (TASS). ($ 7.945 Million)
  - Use high-temperature superconducting (HTS) filters for a variety of sensor systems to bypass traditional impediments caused by radiating high power radar aboard ships.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)										DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-08					
COST (*In Millions*)	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost to Complete	Total Cost
Beyond Silicon MPT-08	0.000	0.000	40.000	50.000	50.000	55.000	60.000	65.000	Continuing	Continuing

(U) **Mission Description:**

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. The Beyond Silicon project will explore alternatives to silicon based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems, and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum computing, new circuit architectures optimizing these new devices, and new computer and electronic systems architectures.

(U) The Beyond Silicon project will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches to electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non-silicon based materials technologies, to achieve low cost, reliable, fast, and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities; from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices. Included in this initiative is Hyperscale Electronics which seeks to develop new electronic device concepts exploiting nano-scale fabrication technologies and novel information transmission phenomena. This project is budgeted in PE0602712E, Project MPT-02 for FY 2001.

(U) As part of the Beyond Silicon project the Quantum Information Science Technology program will develop information technology devices and systems that leverage quantum effects, and will develop techniques for scalable and reliable quantum information processing. Quantum computers are potentially capable of massive computational power infeasible with today's classical computers, and can serve the increasing need for computational power to meet the stringent requirements of military data and signal processing. The program will create mature devices, including circuits, storage, and input-output mechanisms for quantum computer, as well as develop techniques to build reliable and fault tolerant systems. Additionally, as traditional information security and assurance techniques are unsuitable in the quantum computation world, the program will explore techniques for secure quantum communication and computation.

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(U) Another part of this project, the Polymorphous Computing Architectures program, will develop a revolutionary approach to the implementation of embedded computing systems to support reactive multi-mission, multi-sensor, and in-flight retargetable missions and reduce payload adaptation, optimization, and verification from years to days to minutes. The program breaks the current development approach of hardware first and software last by moving beyond conventional silicon to flexible polymorphous computing systems. The key efforts are: 1) define critical reactive computing requirements and critical micro-architectural features; 2) explore, develop, prototype reactive polymorphous computing concepts; 3) explore, develop, prototype multi-dimensional verification and validation techniques for dynamic reactive missions; and 4) provide early experimental testbeds and a final prototype polymorphous computing system.

(U) Finally, this project continues and expands research in molecular electronics (Moletronics) initially funded in 6.1 to demonstrate the integration of multiple molecules, nanotubes, nano-wires, etc., into scalable, functional devices that are interconnected to the outside world with the potential to provide low power, a wide range of operating temperatures and much greater density. The research will also demonstrate the scalability of molecular scale electronics to circuits containing 10^11 elements and for densities equivalent to 10^11/cm^2 and show that hierarchical self-assembly processes can be employed to build the molecular circuits.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Initial funding request contained within this PE under Project MPT-02.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-08

(U) **FY 2002 Plans:**

- Hyperscale Electronics. ($ 11.500 Million)
  - Develop electronic device concepts exploiting nano-scale fabrication technologies and novel information transport phenomena.
  - Develop fabrication processes for implementing new switching device concepts and interconnection technologies with performance levels beyond silicon scalability.
  - Develop methods for static characterization of devices.
  - Develop processes for creating nano-structured materials with appropriate surface and bulk properties.

- Quantum Information Science & Technology. ($ 5.000 Million)
  - Investigate alternative designs and devices for low overhead fault tolerant computational architectures including solid state, quantum bit (qubit) memory and reliable generation of entangled qubits using a controlled NOT gate.
  - Determine architecture and design feasibility quantum solutions for problems such as graph isomorphism, imaging, and signal processing.
  - Investigate alternative protocols for secure quantum communication, quantum complexity, and control.
  - Explore designs that can be potentially implemented in existing fiber plants and free space, and these include high-energy coherent state mechanisms, and polarization compensation.

- Polymorphous Computing Architectures. ($ 6.500 Million)
  - Characterize and perform functional decomposition of pivotal reactive system algorithms and computing functions.
  - Develop a representative scalable benchmark suite.
  - Develop and evaluate initial polymorphous computing architecture concepts.
  - Develop multi-dimensional reactive computing optimization, verification techniques.
  - Implement early prototyping of reactive concepts, software services.

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- Moletronics ($ 17.000 Million)
  - Characterize and optimize molecular-based devices such as switches, multi-state molecules and molecules exhibiting highly non-linear characteristics such as negative differential resistance.
  - Demonstrate that nano-wires have conductivities near that of bulk metal.
  - Quantify the defect-tolerance required for a molecular-based computer to still function.

(U) **FY 2003 Plans:**

- Hyperscale Electronics. ($ 17.500 Million)
  - Determine scalability and limits of device technologies.
  - Implement circuits consisting of novel devices.
  - Confirm dynamic functionality and develop technologies for characterizing transient and steady-state performance of devices and circuits.
  - Demonstrate robust nano-scale assembly processes for functionalizing prepared material surfaces.

- Quantum Information Science & Technology. ($ 6.000 Million)
  - Develop models and scalable implementation of distributed quantum computation, including teleporting logic over significant distances.
  - Explore challenges for scaling of bit rate-distance product for quantum secure fiber optic and free-space links, via the design of repeaters that leverage teleportation and efficient sources
  - Develop methods for simulating large quantum problems on a smaller quantum computer; applications to domains such as bond-selective chemistry.

- Polymorphous Computing Architectures. ($ 11.500 Million)
  - Evaluate and prioritize high payoff malleable micro-architecture features that will support a broad spectrum of reactive computing models.
  - Develop common baseline polymorphous computing architecture framework for incorporation by CORE community.

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  - Develop a multi-dimensional monitoring and verification approach for reactive computing missions.
  - Perform early testing and evaluation on small testbeds.

- Moletronics. ($ 15.000 Million)
  - Develop hierarchical directed assembly processes to assemble molecular devices, wires, and interconnects.
  - Demonstrate efficient defect-search algorithms.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	17.187	26.821	42.700	55.000	65.986	73.986	63.986	63.986	Continuing	Continuing
Advanced Aerospace Systems ASP-01	17.187	26.821	42.700	55.000	65.986	73.986	63.986	63.986	Continuing	Continuing

(U) **Mission Description:**

(U) The Advanced Aerospace Systems program element (PE) is budgeted in the Advanced Technology Development budget activity because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical and space systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. This PE satisfies an Agency requirement for a dedicated host for aerospace research that has progressed beyond the applied research stage and no longer belongs in the 6.2 based Tactical Technology program element (PE 0602702E).

(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program will demonstrate an inexpensive supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities (MALD was funded in FY 1999 from Project TT-06, PE 0602702E). An advanced unmanned air vehicle avionics development and emerging payload effort will be incorporated into the MALI core program due to the required data transmit/receive survivability configuration of the interceptor mission.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. DARPA, in partnership with the Office of Naval Research (ONR) and industry, has formulated the Advanced Air Vehicle (AAV) program to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and flight test of this scaled vehicle concept will

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

be conducted to validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing (VTOL) and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL unmanned air vehicle (UAV) with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. Both the Canard Rotor/Wing (CRW) and A160 are being explored for surveillance and targeting, communications and data relay, lethal and non-lethal weapons delivery, assured crew recovery and special operations missions in support of Navy, Marine Corps, Army and other Agency needs.

(U) The Orbital Express Space Operations Architecture program will develop and demonstrate robotic techniques for on-orbit preplanned electronics upgrade, refueling and reconfiguration of satellites that could support a broad range of future U.S. national security and commercial space programs. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension ("Pre Planned Product Improvement," or "P3I"), comparable to what is done today with aircraft. During Phase I (Concept Definition) the type of satellite servicing to be emulated in the on-orbit demonstration will be identified (to include the type of hardware upgrades and reconfiguration to be supported, and the techniques to be adopted in transferring hardware and fuel between spacecraft), and detailed designs will be developed for "industry standard," nonproprietary satellite-to-satellite mechanical and electrical interfaces enabling on-orbit hardware and fluid transfers. A preliminary system design will emerge in conjunction with developments in software and sensors necessary for robotic space operations to assess the potential significant cost savings for space operations. In Phase II, detailed design of the on-orbit demonstration spacecraft (the service vehicle, the demonstration "target," or serviced satellite, and the depot for replacement hardware and fuel) will occur and the spacecraft will be fabricated, integrated, ground tested, and space-qualified. Finally, in FY 2004, the demonstration spacecraft will be launched. On-orbit, the Orbital Express spacecraft will repeatedly demonstrate the feasibility of robotically upgrading, refueling and reconfiguring satellites. (The FY 2001 funding of this program's technology development is exploiting the development of advanced tactical technology concepts and compact laser technologies (approximately $5 million) funded under PE 0602702E, Project TT-06 in FY 2000 as well as other efforts in this Project, ASP-01.)

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Advanced Air Vehicle (AAV). ($ 10.175 Million) [Future Combat Systems – related = $5.000 Million]
  - Continued propulsion, aerodynamic and flight control risk reduction activities for Canard Rotor/Wing (CRW) concept.
  - Completed preliminary and detailed design and began fabrication of two CRW demonstrators.
  - Completed fabrication of two A160 prototypes; conducted ground tests and initiated flight tests.

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 3.991 Million)
  - Conducted Critical Design Review to establish vehicle configuration.
  - Conducted engine and infrared (IR) payload testing.
  - Initiated fabrication, assembly and risk reduction testing of air vehicle.
  - Developed airborne inter-vehicle communications, mission processing and execution capability.
  - Initiated test planning for flight demonstration of interceptor and collaborative formation mission.
  - Explored other concepts for low cost MALI airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, and jamming.

- Orbital Express Space Operations Architecture. ($ 3.021 Million)
  - Initiated Phase I to: identify, define and analyze the requirements for on-orbit satellite servicing; perform utility, cost effectiveness and life-cycle cost analysis; refine an Operational System Concept (OSC); nominate a baseline satellite servicing mission; and, define a servicing concept of operations (CONOPS).

(U) **FY 2001 Plans:**

- Advanced Air Vehicle (AAV). ($ 3.000 Million)
  - Continue fabrication and conduct hardware in the loop and ground testing of CRW demonstrators.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

- Continue flight tests of A160 air vehicle.
- Design sensor integration modifications to A160 air vehicle.
- Design low-vibration rotor modifications for A160.
- Design unmanned ground vehicle (UGV) deployment system for A160.
- Study A160 scaling and signature reduction.

• Supersonic Miniature Air-Launched Interceptor (MALI). ($ 6.948 Million)
- Complete air vehicle fabrication, assembly and conduct ground testing.
- Demonstrate inter-vehicle communications, mission processing and execution capability.
- Perform supersonic engine flight verification and seeker/advanced payload verification.
- Conduct flight demonstration of supersonic vehicle interceptor and collaborative formation flying mission.
- Conduct free flight intercept demonstration against a representative target.
- Continue to explore alternative mission concepts for low cost MALI airframes, including ground-launched variant of interceptor vehicle for use by land forces.

• Orbital Express Space Operations Architecture. ($ 16.873 Million)
- Complete Phase I to: identify, define and analyze the requirements for on-orbit satellite servicing; perform utility, cost effectiveness and life-cycle cost analysis; refine an Operational System Concept (OSC); nominate a baseline satellite servicing mission; and, define a servicing concept of operations (CONOPS).
- Perform risk reduction R&D activities of critical items identified in system requirements review.
- Conduct preliminary design review in preparation for Phase II.

(U) **FY 2002 Plans:**

• Advanced Air Vehicle (AAV). ($ 10.000 Million)
- Complete fabrication of Canard Rotor/Wing (CRW) demonstrators.
- Complete Canard Rotor/Wing (CRW) ground tests.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

- Initiate CRW demonstrator flight tests.
- Fabricate and test low vibration rotor modifications for A160 air vehicle.
- Integrate/demonstrate electro-optic/infrared (EO/IR) surveillance payload on A160 vehicle.
- Integrate/demonstrate unmanned ground vehicle (UGV) deployment system on A160 vehicle.

• Supersonic Miniature Air-Launched Interceptor (MALI). ($ 2.000 Million)
- Complete supersonic vehicle testing, final report and transition.

• Orbital Express Space Operations Architecture. ($ 30.700 Million)
- Initiate Phase II of the demonstration system (Phase II will complete development, and ultimately conduct an on-orbit test, of the Orbital Express Demonstration System (OEDS)).
- Complete demonstration system detailed design including standard (non-proprietary) satellite-to-satellite electrical and mechanical interfaces.
- Develop key enabling technologies and continue risk reduction activities.
- Initiate fabrication of demonstration system/subsystems.

(U) **FY 2003 Plans:**

• Advanced Air Vehicle (AAV). ($ 14.000 Million)
- Complete flight tests of CRW demonstrators and A160 air vehicles.
- Fabricate forward pass mini control station for A160.
- Flight demonstrate forward pass operations with EO/IR and UGV deployment system on A160.
- Flight test low vibration rotor modifications for A160.
- Develop compound helo modification for A160.

• Orbital Express Space Operations Architecture. ($ 41.000 Million)
- Continue fabrication of Autonomous Space Transfer and Robotic Orbiter (ASTRO) and Next Generation Satellite (NEXTSat).
- Continue Auto Guidance, Navigation and Control (GN&C) system and software design.

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- Perform system tests on Orbital Express hardware.
- Perform ground tests of Orbital Express system/subsystems.

(U) **Program Change Summary:** *(In Millions)*

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	17.071	26.821	32.700	40.000
Current Budget	17.187	26.821	42.700	55.000

(U) **Change Summary Explanation:**

FY 2000 Increase reflects minor program repricing.

FY 2002 - 03 Increases reflect expansion of the Orbital Express Space Operations Architecture effort and expansion of A160 air vehicle technology development.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jun 00	Miniature Air-Launched Interceptor (MALI): Perform engine critical design review.
Aug 00	AAV: Complete A160 flight control system testbed flights.
Aug 00	MALI: Perform Critical Design Review (CDR) after conducting performance trades.
Sep 00	Advanced Air Vehicle (AAV): Initiate A160 air vehicle ground and flight tests.
Sep 00	Miniature Air-Launched Interceptor (MALI): Perform seeker captive carry flight-testing.

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Oct 00	Orbital Express Space Operations Architecture (OESOA): Complete concept definition and mission utility analysis. Select baseline mission and satellite-to-satellite interface concepts.
Dec 00	OESOA: Conduct system requirements review.
Jan 01	MALI: Complete engine altitude chamber testing.
Mar 01	MALI: Deliver first supersonic engine.
Mar 01	MALI: Complete avionics environment verification testing.
Apr 01	OESOA: Complete on-orbit demonstration test plan, and program risk assessment and mitigation plan.
May 01	MALI: Conduct flight readiness review.
Jun 01	MALI: Perform formation flight demo.
Aug 01	MALI: Perform intercept flight demonstration.
Aug 01	AAV: Conduct hardware in the loop and ground testing of Canard Rotor/Wing (CRW).
Aug 01	AAV: Design review for low-vibration rotor modifications and unmanned ground vehicle deployment system for A160.
Sep 01	OESOA: Preliminary design review.
Jan 02	OESOA: Critical design review.
Mar 02	MALI: Complete supersonic flight demonstrations.
Mar 02	AAV: A160 Electro-Optic/Infrared (EO/IR) payload first flight.
May 02	AAV: Complete CRW ground testing.
Jun 02	AAV: A160 Unmanned ground vehicle deployment system first flight.
Jul 02	AAV: Initiate CRW flight tests.
Mar 03	AAV: A160 low vibration rotor first flight.
Jun 03	AAV: Complete flight tests of CRW demonstrators.
Jun 03	OESOA: Ground test of Guidance, Navigation and Control (GN&C) software and docking mechanism hardware.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	245.955	191.800	178.264	168.867	174.354	154.954	134.954	134.954	Continuing	Continuing
Uncooled Integrated Sensors MT-03	10.599	11.916	6.930	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Electronic Module Technology MT-04	51.066	43.684	45.772	48.067	48.029	46.829	46.829	46.829	Continuing	Continuing
Tactical Information Systems MT-05	23.368	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Centers of Excellence MT-07	5.364	4.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Manufacturing Technology Applications MT-08	15.484	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Lithography MT-10	45.679	45.012	25.013	25.000	25.000	25.000	0.000	0.000	0.000	N/A
MEMS and Integrated Micro-systems Technology MT-12	72.916	37.712	37.590	24.000	24.025	10.825	10.825	10.825	Continuing	Continuing
Mixed Technology Integration MT-15	21.479	49.476	62.959	71.800	77.300	72.300	77.300	77.300	Continuing	Continuing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

(U) **Mission Description:**

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the US industrial base.

(U) The Uncooled Integrated Sensors project addresses a long-standing Defense requirement for uncooled infrared sensor arrays for major weapons systems that cannot accommodate costly cryogenic cooling packages.

(U) The Electronic Module Technology project is a broad initiative to decrease the cost and increase the performance of weapon systems through the insertion of electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability. Further improvements require microcircuits with smaller features to meet the operational seed, power, weight and volume constraints.

(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards and physiological states.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

(U) The goal of the Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Three on-going DARPA projects are nearing completion. Both the Tactical Information Systems (MT-05) and the Manufacturing Technology Applications (MT-08) projects end in FY 2000. The Tactical Information Systems project is designing and developing prototype modules, using core technologies that sense, think and communicate, and integrating them into selected personal information products. The project is also demonstrating the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters. The Manufacturing Technology Applications project goal is to reduce the cost and acquisition lead-time of future military systems by integrating manufacturing process considerations during the product design phase and by demonstrating high efficiency multi-product prototype factories. This project enables manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies. The Centers of Excellence (MT-07) project finances demonstration, training and deployment of advanced manufacturing technology. This effort will transition to state/private support during FY 2001.

(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	252.388	191.800	188.264	173.867
Current Budget	245.955	191.800	178.264	168.867

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects below threshold reprogramming, minor program repricings, and SBIR reprogramming .

FY 2002 Decrease reflects phase down of Advanced Lithography in preparation for technology transition. This is partially offset by an increase in the Mixed Technologies project for the new initiative in Biofluidics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

FY 2003 Decrease reflects Advanced Lithography program phase down and transition of technology. This decrease is partially offset by an increase in the Mixed Technology project associated with the major new initiative in Wavelength Division Multiplexing for Military Platforms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-03					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Uncooled Integrated Sensors MT-03	10.599	11.916	6.930	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared sensor arrays essential to major weapon systems. The focal plane array consists of a two-dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two-dimensional sensor array without the cryogenic package usually associated with infrared sensors. Thermal Imaging Devices will develop new imaging at the theoretical limit, (five to fifty times increase over current uncooled devices), achieving high performance in extremely small, low power configurations and demonstrating technology to open new applications for imaging devices.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Uncooled Imaging Sensors. ($ 2.599 Million)
  - Demonstrated 480x640-uncooled arrays with < .05 milli-Kelvin, 1 mil pixel.
  - Transferred 480x640 uncooled infrared sensor to Army missile seeker program.
  - Conducted field evaluation of high sensitivity uncooled infrared sensor with low light sensor for ground operations.

- Thermal Imaging Devices. ($ 8.000 Million)
  - Demonstrated non-contact read-out devices and characterized sensitivity/noise sources.
  - Demonstrated non-contact imaging array with thermal sensitivity of 100 milli-Kelvin.

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(U) **FY 2001 Plans:**

- Thermal Imaging Devices. ($ 11.916 Million)
  - Demonstrate 100 gram imaging sensor with performance acceptable for micro-air-vehicles.
  - Optimize read-out structure to read signals with short (approximately 1 msec.) integration time.

(U) **FY 2002 Plans:**

- Uncooled Imaging Sensors. ($ 6.930 Million)
  - Operate uncooled infrared detection at or near the theoretical limit of less than 0.01 Kelvin.
  - Provide uncooled sensor performance compatible with advance combat vehicles and missile seeker requirements.

(U) **FY 2003 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Sept 00	Field evaluation of high sensitivity uncooled sensor with low light level sensor for ground operations.
Nov 00	Demonstrate 100 gram imaging sensor with performance acceptable for micro-air-vehicles.
Sept 01	Demonstrate 50 gram sensor with sensitivity of 20 milli-Kelvin.
Jan 02	Incorporate high responsitivity materials into detector structure.
Mar 02	Integrate materials and microstructure into imaging device.
Sept 02	Demonstrate five-gram sensor with sensitivity < 5 milli-Kelvin, ideal thermal imaging device.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04					
COST (*In Millions*)	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Electronic Module Technology MT-04	51.066	43.684	45.772	48.067	48.029	46.829	46.829	46.829	Continuing	Continuing

(U) **Mission Description:**

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards, and emerging technologies such as high density Multichip Modules.

(U) The project has three major objectives: (l) shorten the overall design, manufacture, test and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; and (3) provide a robust manufacturing infrastructure for electronic modules.

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Distributed Robotics; Design Support for Mixed Technology Integration (Composite CAD), the Molecular-level Large-area Printing (MLP) and the Nano Mechanical Array Signal Processors (NMASP) program. Photonic Analog/Digital (A/D) conversion will utilize breakthrough photonic developments to substantially increase the speed that analog signals are converted into digital data streams for data reduction and processing. Distributed Robotics is an effort to integrate developments in Microelectromechanical Systems (MEMS), power sources, communications and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into "systems-on-a-chip" and other highly integrated mixed technology systems. The MLP program is exploring approaches to 'print' MEMS devices on large surfaces. An initiative to create arrays of precision, nano mechanical structures for RF-signal processing is planned. The NMASP program will create arrays of precision, nano mechanical structures for radio frequency (RF) signal processing that will greatly reduce the size and power consumption of various communication systems.

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Photonic A/D. ($ 14.787 Million)
  - Evaluated alternative photonic clock, optical sampler and quantizer module designs for photonic A/D converters operating in the 10-100 Giga-sample-per-second range.
  - Identified high impact applications for this technology.

- Distributed Robotics. ($ 12.378 Million)
  - Demonstrated feasibility of a variety of multiple robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions.
  - Demonstrated probability of mission success improved by distributed functionality.

- Composite CAD. ($ 9.582 Million)
  - Completed the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enabled designs and micro fluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip.
  - Provided mixed technology design libraries, models and test structure data to improve design quality, development time and ability to reuse designs.

- Molecular-level Large-area Printing (MLP). ($ 14.319 Million)
  - Concentrated on the development and choice of non-conventional large-area, MLP techniques for a demonstration system.
  - Established overlay capabilities for MLP.

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(U) **FY 2001 Plans:**

- Photonic A/D. ($ 16.178 Million)
  - Complete initial photonic A/D converter evaluation and finalize design for demonstration module.
  - Demonstrate key photonic technologies.

- Distributed Robotics. ($ 14.678 Million)
  - Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

- Molecular-level Large-area Printing (MLP). ($ 12.828 Million)
  - Demonstrate and characterize 10,000 x 100 pixel density array on a spherical surface.

(U) **FY 2002 Plans:**

- Photonic A/D. ($ 18.906 Million)
  - Complete photonic analog/digital converter technology development.
  - Integrate photonic clock and sampler modules with electronic quantizers.
  - Complete analog/digital converters with at least 10 gigasamples/sec.
  - Demonstrate high linearity and dynamic range.

- Distributed Robotics. ($ 10.942 Million)
  - Complete current contracts on micro robot developments.
  - Deliver prototype hardware and final reports.
  - Demonstrate with operational military users.

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- Nano Mechanical Array Signal Processors (NMASP). ($ 15.924 Million)
  - Initiate development of nano mechanical array signal processors that will enable ultra miniaturized (wristwatch or hearing aid in size) and ultra low power UHF communicators/GPS receivers.
  - Demonstrate innovative 3-dimensional nano device design and fabrication capabilities.
  - Demonstrate resonant frequencies at UHF (300MHz to 3GHz).
  - Demonstrate temperature stability and long-term drift.
  - Demonstrate electrically controlled tunability suitable for UHF communication.

(U) **FY 2003 Plans:**

- Nano Mechanical Array Signal Processors (NMASP). ($ 25.067 Million)
  - Demonstrate arrays up to 1024 nano devices with geometrical control and material uniformity at ± 20 percent, and to ± 1 percent with trimming and tuning.
  - Demonstrate interconnect and isolation (multiplexed, serial, or random access of individual resonators).
- Nano Array Process Integration. ($ 23.000 Million)
  - Demonstrate process integration with CMOS device with system optimization and impedance matching among electronic and mechanical circuits at the appropriate frequencies.
  - Demonstrate on-die hermetic packaging for all-mechanical RF front end.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Jun 00	Establish overlay capabilities for MLP.
Jul 01	Demonstrate and characterize 10,000x 100-pixel density array on spherical surface.
Aug 01	Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.
Jul 02	Develop 3-D nano resonator.
Jul 03	Develop uniform nano arrays.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Tactical Information Systems MT-05	23.368	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project will develop the technology for transmitting and displaying critical situational awareness and surveillance information to the warfighter. This project consists of Warfighter Visualization efforts. These efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer-generated information. Together these systems will provide the mounted and dismounted warfighter with an unprecedented awareness in the most hostile environments.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Warfighter Visualization. ($ 23.368 Million)[Future Combat Systems – related = $3.000 Million]
  - Demonstrated a high performance special purpose processor that took the capabilities of real-time georegistration and precision targeting and integrated them onto a single chip. This miniaturized the system for vehicle mounting or ultimate portability by a dismounted soldier or in handheld units such as night vision goggles.
  - Demonstrated a prototype advanced human interface capability for use in conjunction with other body worn processing units. This system combines "supernormal" listening with tactile inputs and displays for a dismounted soldier.
  - Demonstrated full-surround foveal vision system for glass turret. This system matches the human visual system by providing high resolution only where it is needed in the visual field, but provides a seamless image using advanced video processing system.
  - Developed change-detection technology to interpret reconnaissance imagery and enhance intelligence community capabilities.

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(U) **FY 2001 Plans:**

- Not Applicable.

(U) **FY 2002 Plans:**

- Not Applicable.

(U) **FY 2003 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Warfighter Visualization:	
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Dec 00	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Centers of Excellence MT-07	5.364	4.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality. This project also includes funding for the Defense Techlink Rural Technology Transfer Project.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Advanced Flexible Manufacturing. ($ 3.864 Million)
  - Expanded the Institute for Advanced Flexible Manufacturing's web-based electronics supply chain support to include 150 small manufacturers who now have access to Defense on-line procurement activities.

- Defense Techlink Rural Technology Transfer Project. ($ 1.500 Million)
  - Provided funding for the Defense Techlink Rural Technology Transfer Project.

(U) **FY 2001 Plans:**

- Advanced Flexible Manufacturing. ($ 4.000 Million)
  - Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

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(U) **FY 2002 Plans:**

- Not Applicable.

(U) **FY 2003 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 01	Complete assessment and transition of the Institute from DoD to state/private support.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08				
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Manufacturing Technology Applications MT-08	15.484	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible multi-product factories, and advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50 percent reductions in the unit cost of tactical missiles, in ongoing missile production programs, in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Affordable Multi-Missile Manufacturing (AM3). ($ 15.484 Million)
  - Completed integration of flexible factory assembly areas.
  - Deployed System Integration Design Environment.

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- Completed design and prototype fabrication of low cost Inertial Measurement Unit (IMU).
- Completed common processor design verification test and integration.
- Validated electronic collaborative tools and completed supplier affordability demonstration.
- Completed integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstration.
- Completed common seeker commercial parts test evaluation, producibility analysis and flight test.
- Completed common IMU design verification test, prototype demonstration unit and technology insertion review.
- Completed flexible multi-product assembly cells process design, validated on production parts and demonstrated on production line.
- Completed electronic procurement and supplier integration demonstrations.
- Designed, built, and tested laboratory and ground vehicle-mounted prototypes of a GPS missile retargeting unit.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **FY 2002 Plans:**

- Not Applicable.

(U) **FY 2003 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Demonstrate a laboratory prototype of a GPS Missile Retargeting Project.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstrations.
Jul 00	Complete electronic procurement and supplier integration demonstrations.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Lithography MT-10	45.679	45.012	25.013	25.000	25.000	25.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) Microelectronics is a key to improved weapon system performance. Lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption and weight. Advanced microelectronics technology is essential for computing and signal processing in virtually all military systems including command, control, communications and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1 micron features.

(U) The goal of the lithography program is to reduce technical barriers to the development of advanced lithographic technologies for the fabrication of a broad range of microelectronic devices and structures. Innovative research in pattern generation and transfer, imaging materials, new process and metrology will provide alternatives beyond current evolutionary trends. The program will investigate technologies for the creation of highly complex patterns at sub 0.10 μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics.

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(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Sub 0.1 Micron Lithographies. ($ 23.851 Million)
  - Developed key tool components, materials and processing to accelerate the availability of emerging lithography technologies beyond 193 nm. Efforts included maskless (electron beam, ion beam) approaches and projection technologies, using optical, electron, x-rays and extreme ultraviolet.
- Support Technologies. ($ 16.000 Million)
  - Developed support technologies, to include mask technology, resists and metrology.
  - Developed innovative optics designs, architectures and new materials, and processing beyond the evolutionary trends in the industry.
- Laser Plasma X-ray Source. ($ 4.861 Million)
  - Continued laser plasma x-ray source technology.
- Point Source Lithography ($ 0.967 Million)
  - Continued point source lithography development.

(U) **FY 2001 Plans:**

- Sub 0.1 Micron Lithographies. ($ 25.900 Million)
  - Demonstrate key components of maskless wafer writer and key components for lithography of 0.07-micron features.
- Support Technologies. ($ 19.112 Million)
  - Accelerate technology developments in the lithography exposure sources and supporting (cross-cutting) technologies needed for microelectronics fabrication.
  - Develop reduced risks in key areas of components, materials and processing allowing industry to fabricate prototype tools and new high-performance devices for use in advanced military systems and commercial markets.

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(U) **FY 2002 Plans:**

- Sub 0.1 Micron Lithography. ($ 15.013 Million)
  - Develop key tool components, materials and processing for both maskless and projection approaches for lithography at 0.07 microns and below.
  - Fabricate prototype devices for military applications with features at 0.1 micron.

- Support Technologies. ($ 10.000 Million)
  - Develop mask technology (writing, inspection and repair), resists and metrology for lithography for sub 0.1 micron.
  - Develop resists that will emphasize thinner resists appropriate for emerging exposure sources.

(U) **FY 2003 Plans:**

- Sub 0.1 Micron Lithography. ($ 15.000 Million)
  - Develop and demonstrate key subsystems for both maskless and projection approaches for lithography technologies that will extend to 0.05 microns and below.
  - Fabricate prototype tools for fabrication of devices with 0.07 micron features.

- Support Technologies. ($ 10.000 Million)
  - Develop mask technology (writing, inspection and repair), resists and metrology for lithography for 0.07 micron and below.
  - Exploit advances from longer term developments in direct write-on-wafer projects.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	Component demonstration of maskless wafer writer.
Aug 02	Demonstrate key components for lithography of 0.07 micron features.
Sep 02	Demonstrate key components for mask writer for sub 0.1 micron features.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
MEMS and Integrated Micro-systems TechnologyMT-12	72.916	37.712	37.590	24.000	24.025	10.825	10.825	10.825	Continuing	Continuing

(U) **Mission Description:**

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS provides the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences to monitor environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Compact portable power sources capable of generating power in the range of a few hundred milliwatts to one watt are critical to providing power for untethered sensors and other chip-scale microsystems. This program aims to replace today's technologies relying on primary and rechargeable batteries, which severely limit mission endurance and capabilities, by extending microelectronic machine technology to develop micro-

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power generators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micro-power generators will be capable of generating sustained power in the desired range for use with remote, field-deployed microsensors and microactuators.

(U) Within this project is the development of totally integrated microfluidic chips to enable ubiquitous yet unobtrusive assessment of the warfighter's body fluids. These microchips integrate detection, diagnostics and treatment in one chip-scale system called Bio-Fluidic chips.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- MEMS Devices and Processes. ($ 18.817 Million)
  - Developed new devices and processes that survive extremely harsh environments and facilitated the integration of micro-mechanical as well as micro-chemical systems into electronic circuits. These new devices include micro power sources, mechanical-microprocessor units, micro actuators, communication components, MEMS aerodynamic pressure sensors on flexible adhesive tape substrate; modular, monolithically integrated MEMS Inertial Measuring Unit (IMU); and MEMS high-temperature sensor and actuator arrays.
  - Demonstrated micro devices that will reduce communication equipment to the size of a credit card; optimized the aerodynamics of an airplane wing for lift and drag, provided intelligence to machine components to allow them to report their condition and state of readiness (e.g., "smart wheel bearings"), and increased the resistance of jamming of GPS used on smart munitions.
  - Integrated power sources with the MEMS devices and expanded the use of MEMS in fluidic applications.

- MEMS System Design and Development Phase II. ($ 16.211 Million)
  - Initiated technology demonstrations relevant to micro airborne sensor/communicator platforms and chemically powered remote sensors, subsystems for Pico Satellites, electromechanical signal processing and nanoelectromechanical systems.

- CAMD. ($ 3.888 Million)
  - Continued micro device manufacturing processes at the Center for Advanced Microstructures and Devices (CAMD).

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- MEMS Micro Power Generation. ($ 25.000 Million)
  - Demonstrated feasibility and practical limits of converting chemical energy into electrical energy on the micro-scale using MEMS technology. The goal is to replace primary and rechargeable batteries with micro power generators that have at least one order of magnitude higher energy density, and thus drastically reducing weight and volume of power sources.
  - Developed high-energy density power generation on micro-scale from fuels.
  - Developed stand alone, remotely distributed MEMS sensor networks.

- Bio-Fluidic Chips (BioFlips). ($ 9.000 Million)
  - Designed micro scale fluidics integrated with optical and/or electronic detection to monitor cellular activities of body fluids.
  - Designed chip interface with bio-fluids for continuous sampling and fluids delivery.
  - Developed on-chip reagent storage and reconstitution.

(U) **FY 2001 Plans:**

- MEMS Micro Power Generation . ($ 19.844 Million)
  - Demonstrate chip-level integration of components for fuel processing, thermal management, energy conversion and exhaust management for micro power generation. Enable stand alone, remotely distributed micro sensors with built-in power supply and RF communication in addition to various sensing functions.
  - Develop MEMS free-piston knock engine.
  - Develop an integrated fuel cell and fuel processor for micro scale power generation from liquid fuels.
  - Develop integrated chemical fuel microprocessor for power generation in MEMS applications.
  - Develop 3-D monolithically fabricated thermoelectric micro generator.

- Bio-Fluidic Chips (BioFlips). ($ 17.868 Million)
  - Develop closed-loop bio-fluidic chips to regulate cellular transduction pathways and precise dosage of chemicals/drugs/ reagents/enzymes.

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- Fabricate and test individual micro fluidic chip components and integrated sensors for flow control.
- Manipulate (pump/valve/sense) bio-fluids in integrable micro fluid components.

(U) **FY 2002 Plans:**

- MEMS Micro Power Generation. ($ 19.789 Million)
  - Demonstrate capabilities in fuel processing, energy conversion to electricity, thermal and exhaust management.

- Bio-Fluidic Chips (BioFlips). ($ 17.801 Million)
  - Demonstrate optimization of sub-systems and components for integration into prototype systems. Sub-systems include: 1) on-chip sample preparation and processing (on-chip flow/concentration regulators, biosignal amplification, on-chip pressure sources, on chip separation/mixing, reagents storage/reconstitution); 2) sample collection (body fluid extractors, concentrators); and 3) antidote synthesis (genetic and antibodies) subsystems.
  - Identify partners in the DoD and other federal agencies for testing prototype systems.
  - Perform preliminary testing of prototype systems for re-evaluation of sub-system functionality.

(U) **FY 2003 Plans:**

- MEMS Micro Power Generation. ($ 10.000 Million)
  - Demonstrate integration of various power-generation components with micro sensors and micro actuators.
  - Demonstrate standalone, remotely distributed micro sensors and actuators with built-in power supply and wireless communication.

- Bio-Fluidic Chips (BioFlips). ($ 14.000 Million)
  - Modify sub-systems based on preliminary testing of prototype systems.
  - Finalize testing of prototype systems to optimize integrated performance.
  - Demonstrate prototype BioFlip systems both in vitro and in vivo.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jun 00	Demonstrate modular, monolithically integrated MEMS Inertial Measurement Unit (IMU).
Aug 00	Demonstrate subsonic roll, pitch and yaw control via MEMS.
Sep 01	Demonstrate atomic resolution data storage.
Aug 02	Demonstrate MEMS micro combustion.
Feb 03	Demonstrate MEMS heat engines.
Sep 03	Demonstrate MEMS electrical power generation.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	21.479	49.476	62.959	71.800	77.300	72.300	77.300	77.300	Continuing	Continuing

(U) **Mission Description:**

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at-a-distance, a paradigm that addresses many of the present and future needs of the DoD. These 'wristwatch size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: Microelectromechanical Systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies. This new paradigm will create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and

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microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability.

(U) The goal of the Wavelength Division Multiplexing (WDM) for Military Platforms program is to develop new materials, components and sub-systems for use in wavelength division multiplexing based optical communications, delivering high capacity, mission adaptable networks for use in data intensive military weapons systems.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Three-D Imaging Devices. ($ 7.746 Million)
  - Initiated program to develop new high speed imaging device technology to rapidly acquire a high-resolution 3-D image of a tactical target at ranges of 7-10 kilometers increasing identification range of tactical targets, especially from fast moving platforms.
  - Developed near infrared materials with point defect density less than 1000/sq cm.
  - Demonstrated 4x4 array of detectors with gain of 30 at 1GHz.
  - Completed investigation of novel high gain detector concept.

- Steered Agile Laser Beams (STAB). ($ 6.630 Million)
  - Initiated program to develop compact, lightweight, man-portable, electronically steered lasers to replace large, heavy gimbal mounted lasers in lasercom links and smart weapon target designators.
  - Developed small, lightweight laser beam scanner system technologies for replacement of gimbaled mirror systems.
  - Initiated system design and component specifications; selected system design.

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- RF Lightwave Integrated Circuits (R-FLICS). ($ 7.103 Million)
  - Initiated program to demonstrate, with heterogeneous integration, lightwave and RF technologies to route, control and process analog RF Signals in the 0.5-50 GHz range.
  - Developed RF-Photonic modules to enable links with better than zero net RF loss from input to output.
  - Developed and demonstrated optically integrated modules capable of performing complex RF functions such as signal channelization or single chip generation of multiple RF signals.

(U) **FY 2001 Plans:**

- Three-D Imaging Devices. ($ 16.825 Million)
  - Complete design of high-speed electronics for sub-nanosecond detection.
  - Integrate high-speed electronics with 5x5-detector array and integrate into brass board imaging system.
  - Demonstrate laboratory imaging with 5x5 array.
  - Select detector design for 128x128 3-D imaging array.

- Steered Agile Laser Beams. ($ 17.825 Million)
  - Develop electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units that are able to transmit images and geo-location data of targets, and for use in target designators for small unit operations in high threat environments.
  - Fabricate beam steering emitters and detectors.

- RF Lightwave Integrated Circuits (R-FLICS). ($ 14.826 Million)
  - Focus program on identified key applications for integrated RF-Photonic modules and produce initial prototypes and demonstrate methods for evaluation of their performance.
  - Initiate parallel efforts to develop components for efficient RF links exhibiting better than zero net loss and to demonstrate the advantages of integrated optical-RF modules for RF systems.
  - Down select among technology options and develop prototype module for demonstration.

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(U) **FY 2002 Plans:**

- Three-D Imaging Devices. ($ 8.906 Million)
  - Demonstrate range imaging at the eye-safe wavelength of 1.54 micrometers, with a minimum array size of 64x64. The goal is target identification range of 10 km with single laser pulse imaging.
- Steered Agile Laser Beams (STAB). ($ 12.860 Million)
  - Analyze system concepts that will be used to develop design goals for assembled components.
  - Fabricated individual laser beam steering components (lasers, diffractive optics, micro electro-mechanical (MEMS) sub-assemblies, detectors, filters and integrated circuits).
  - Resolve component interface issues in preparation for breadboard development.
- RF Lightwave Integrated Circuits (RFLICS). ($ 10.383 Million)
  - Determine the quantitative performance requirements of computationally intensive weapons systems tasks such as RF channnelization, local oscillator distribution, antenna beam forming, jammer nulling, signal synthesis and frequency conversion.
  - Use results of earlier RF photonics single chip development effort to establish goals for RF photonic component fabrication.
  - Integrate recently developed emitters, waveguides, detectors and integrated circuits to produce RF photonic component prototypes.
- Wavelength Division Multiplexing (WDM) for Military Platforms. ($ 13.510 Million)
  - Conduct modeling, simulation and analysis of artificial dielectrics and new materials for ultra-compact Wavelength Division Multiplexing (WDM) components.
  - Conduct experimental efforts in the growth and fabrication of these new materials and determine suitable processing procedures.
  - Plan construction of WDM components.
- Engineered Molecular Flow Devices (Biofluidics). ($ 17.300 Million)
  - Develop robust techniques to fabricate on-chip bilayer lipid membranes (BLM) and/or membranes with nanofabricated pores.
  - Integrate sensors for read-out of molecular flow components.

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- Demonstrate on-chip molecular flow control single components via 1) embedded proteins receptors in bilayer lipid membranes (BLM); and 2) micromachined membranes with nanochannels.
- Design processes to fabricate arrays of molecular flow control devices including interconnect microfluidics and electronics.

(U) **FY 2003 Plans:**

- Steered Agile Laser Beams (STAB). ($ 11.000 Million)
  - Evaluate competing laser beam steering component technologies; down-select to the most promising approaches.
  - Complete prototype design studies.
  - Assemble and test components suitable for use in prototype demonstration and evaluation.
  - Assess performance characteristics of the prototypes and make recommendations for future development.

- RF Lightwave Integrated Circuits (RFLICS). ($ 6.000 Million)
  - Complete the design and fabrication of RF photonic prototypes.
  - Construct testbeds capable of producing realistic systems demands for the demonstration and evaluation of RF lightwave integrated circuit components and assemblies.
  - Measure and analyze the operational impact of the photonic domain for advanced RF signal transmission, conditioning and processing.

- Wavelength Division Multiplexing (WDM) for Military Platforms. ($ 32.500 Million)
  - Design, fabricate and test novel WDM components using the new materials and processing technology.
  - Determine fiberoptic and planar waveguide interconnection requirements.
  - Evaluate the suitability of the new components for use in prototype modules.
  - Down-select to the most promising approaches and begin prototype module assembly.
  - Construct testbeds capable of fully measuring and characterizing the new technologies implemented in the chip-scale WDM components.
  - Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.

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- Engineered Molecular Flow Devices (Biofluidics). ($ 22.300 Million)
  - Test and optimize functionality of molecular flow control arrays.
  - Determine prototype molecular flow processor functionality and specifications.
  - Design molecular flow signal processing protocols.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
3-D Imaging:	
Aug 00	Demonstrate detector test arrays with gain/bandwidth product capable of sub-nanosecond detection at long range.
Feb 01	Integrate novel, high gain/bandwidth detector array with low noise electronics.
Jun 02	Demonstrate range imaging at eye safe wavelengths.
Steered Agile Laser Beams:	
Aug 01	Fabricate beam steering emitters and detectors.
Jul 02	Fabricate laser beam steering components.
May 03	Complete prototype design studies.
R-FLICS:	
Feb 01	Demonstrate High Performance R-FLIC Components to 50 GHz bandwidth.
Aug 01	Demonstrate integrated R-FLIC functions such as channelizer with 10 GHz selectivity over 0-50 GHz bandwidth.
Aug 02	Integrate emitters, waveguides and detectors into RF photonic component prototypes.
Sep 03	Complete design and fabrication of RF photonic prototypes.

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WDM:

Aug 02	Develop artificial dielectrics suitable for compact WDM modules.
Aug 03	Design, fabricate, and test WDM modules.

Biofluidics:

Aug 02	Demonstrate on-chip molecular flow control.
Apr 03	Determine prototype molecular flow processor specifications.

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COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	176.846	128.863	107.188	99.480	99.746	108.071	103.071	103.071	Continuing	Continuing
Command & Control Information Systems CCC-01	97.657	79.209	63.068	67.234	70.234	73.234	67.234	67.234	Continuing	Continuing
Information Integration Systems CCC-02	79.189	49.654	44.120	32.246	29.512	34.837	35.837	35.837	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. Projects include: the Man and Machine Command and Control (M2C2) program, the Information Assurance Science and Engineering Tools; the Advanced Intelligence, Surveillance and Reconnaissance (ISR) Management (AIM) program; the Agent-Based Systems program; Project Genoa; the Active Templates program; Reliable Mobile Agents for Hostile Military Environments; Virtual Mission, Planning and Training for Countering the Asymmetric Threat; Cyber Sensor Grid; and Bio-Surveillance.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real-time basis. Programs addressed in this project include: the Dynamic Database (DDB) program; the Airborne Communications Node (ACN) program; the Command Post of the Future program; Symbiotic Communications; and Bandwidth Solutions.

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(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	185.926	128.863	130.688	136.480
Current Budget	176.846	128.863	107.188	99.480

(U) **Change Summary Explanation:**

FY 2000	Decrease reflects minor program repricings and SBIR reprogramming.
FY 2002	Decrease reflects the completion of the JFACC, AICE, and Dynamic Command and Control Systems programs.
FY 2003	Decrease reflects the completion of the Command Post of the Future and Airborne Communication Node programs.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Command & Control Information Systems CCC-01	97.657	79.209	63.068	67.234	70.234	73.234	67.234	67.234	Continuing	Continuing

(U) **<u>Mission Description:</u>**

(U) Military operations that have taken place since the end of the cold war have demonstrated that current theater command, control, communications, intelligence/information systems, and planning and rehearsal systems lack the ability to fully support operations in complex, time-critical environments. These operations range from conflict and peacekeeping in urban areas to heavy battle actions in remote areas. Current capabilities do not provide the Commander with real time, secure, situational awareness nor the ability to orchestrate high-tempo planning, rehearsal and execution. The goals of the programs in this project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the Commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability, and provide secure multimedia information interfaces and assured software to "on the move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through assured information systems.

(U) The Joint Force Air Component Commander (JFACC) Program sought to address critical issues in military command and control (C2), specifically addressing joint and coalition air operations. In the earlier phases of the program, it was noted that as each C2 element (observation, orientation, decision, and execution) was driven toward progressively shorter timelines, dynamic instabilities in the decision loop became the key challenge to practical implementation of any new generation of C2 systems. JFACC developed and validated new C2 architectural concepts and appropriate control strategies with the ability to: (1) rapidly and efficiently respond to varying objectives and guidance, time constraints, changeable resources, erratic hostile responses, asymmetric threats and unpredictable anomalies (Agility); (2) proactively manage destabilizing events, such as time critical targets, while simultaneously avoiding undesirable long-and short-term effects, to include disruptive and inefficient impacts on downstream plans and operations (Stability); and (3) adapt to the wide spectrum of military conflicts and activities, including control of unmanned assets (Flexibility). The program validated that utilizing computer-driven tools to shorten the processing time in each of the processes in the decision cycle has had no appreciable impact on the ability to address time-critical requirements (such as targeting). The last phase of the JFACC program demonstrated the efficacy of using the mathematics and science of control theory as a foundation for generating a dynamic military C2 architecture.

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(U) Building upon the results of previous C2 efforts, the Man & Machine Command & Control (M2C2) program will generate dynamically adaptable C2 architectures and tools to allow the commander to understand and make critical decisions within a complex, time-constrained environment. The M2C2 program will enable the commander to institute autonomic responses to a wide variety of sensor-determined threats and control both human and machine (robots, sensor grids) in a coordinated manner. This program will provide the commander with the technological C2 tools, which that will, for the first time, allow real-time response in a dynamic, complex, high tempo environment.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. In FY 2000, the program that has been addressing such key issues, Information Assurance (IA), is coming to a close and the Information Assurance Science and Engineering Tools (IASET) program is addressing new issues while incorporating lessons learned from the IA program. The IASET program will address the IA problem by developing the underlying science that will allow us to formally understand the problem at hand and by developing the engineering tools and an integrated environment that designers and assessors can use to solve real IA problems and reliably quantify the assurance of their systems. These new methods will approach problems with a truly "system level" viewpoint, and must be based in the science of information and on sound engineering principles. They must enable the designer and analyst to capture and probe the causality, relationships, and objectives of an entire system. The results will be demonstrated and used in actual projects addressing important evolving requirements such as malicious code mitigation. Successful demonstrations will significantly aid in the transition of this environment into DoD and commercial applications.

(U) The coming generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) program will develop Collection Strategies and Multi-asset Synchronization components to dynamically optimize/synchronize, schedule, and task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM project will optimize ISR support to precision engagement and tactical operations by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM will insure near-real-time (NRT) information support to commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making.

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(U) The Control of Agent-Based Systems (CoABS) Program will explore the ability to rapidly assemble a set of disparate information systems into a coherently interoperating whole. This will be done without having to redesign legacy systems and will include interoperation with non-DOD governmental systems and open-sourced systems not built to a pre-existing government standard. The development and implementation of mobile agents and agent-communication languages will help both in the facilitation of the multi-systems integration and in controlling the information flow to alleviate bandwidth saturation and degraded quality of service. The Control of Agent-Based Systems Program will demonstrate and deploy a middleware-based approach, and eventual toolkit, for the support of the interoperable heterogeneous systems which are a critical need for coalition operations and which will enable the interaction of military and non-military resources in critical operations.

(U) Project Genoa is developing tools and a prototype infrastructure for collaborative crisis understanding and management for the national security community ranging from the National Command Authorities to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. To develop timely preemptive or mitigating strategies, Project Genoa's objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. The current clients for components of the prototype system are Commander in Chief Pacific (CINCPAC) and Defense Intelligence Agency (DIA).

(U) The Active Templates (AcT) program will produce a robust, lightweight software technology for aiding in the automation of detailed planning and execution for military operations using a plan spreadsheet metaphor. Active Templates are distributed data structures whose variables will be linked to live data feeds or problem-solving methods. Active Templates will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, scalable, and widely adopted. As a result, the technology to be fielded will provide faster plan generation (6 times), improved plan quality (8 times more options considered), 60 percent reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis.

(U) Reliable Mobile Agents for Hostile Military Environments – Mobile agents will provide a revolutionary improvement in limited bandwidth military communications, dramatically increasing bandwidth utilization, reliability, fault tolerance and security. This approach will have

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significant impact on solving problems unique to military environments, as mobile agents will provide much better utilization of limited bandwidth communication channels that may also be facing electronic warfare threats. Current forms of mobile code pose unacceptable security risks. These commercially available forms of mobile code represent only an infancy of capabilities with little exploration of possible security gains.

(U) Virtual Mission, Planning, Training and Rehearsal for Countering the Asymmetric Threat - Virtual synthetic information in combination with real data will provide a revolutionary improvement in environmental and adversarial attribute data, dramatically increasing the levels of realism and applicability that operators will be able to employ in preparation for mission execution. This approach will have significant impact on solving planning problems unique to military small unit operations. Virtual intent models, activity simulations and environmental data will provide a much timelier and better representation of the mission at hand.

(U) With the increasing threat of a biological attack against the U.S., it is critical to improve our ability to rapidly detect the release of a biological agent against U.S. military and civilian targets. If a biological agent, such as anthrax or smallpox, was clandestinely released in a U.S. city, the health care system may not correctly diagnose the release until hundreds were dead and thousands more were too seriously infected to receive treatment. The Bio-Surveillance program will develop the technology necessary to integrate traditional and non-traditional sources of health care data and automatically detect the occurrence of anomalous events such as the sudden increase in medical symptoms, which may be caused by a biological attack. A prototype system will be implemented and tested in simulated exercises to demonstrate the ability to detect the clandestine release of a biological agent several days before they would be detected using current health care reporting techniques.

(U) Cyber Sensor Grid – The goal of this program is to insert prototype functionally into test environments for experimentation. The results of this experimentation can then be leveraged for solution sets that can be applied to systems architectures.

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 2000 Accomplishments:</u>**

- Joint Force Air Component Commander (JFACC). ($ 20.950 Million)
  - Developed a reconfigurable model that simulates the dynamic phenomena within the military air operations enterprise. Using the enterprise model, identify the dynamic behaviors within military air operations, which must be stabilized by the application of innovative control strategies.

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- Experimentally investigated the stability effects of new control technologies and C2 architectures incorporated within the air operations enterprise model.
- Validated the feasibility of a 10-fold reduction in the time to initiate a required change in operations, with accurate understanding of side and downstream effects.

• Information Assurance. ($ 35.498 Million)

- Demonstrated automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules.
- Demonstrated real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Coupled advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration.
- Dynamically and automatically managed allocation of components and resources to reconstitute critical functions that have been degraded.
- Demonstrated security policy interoperability between enclaves. Explored knowledge base approach to adaptive systems management. Improved assurance measurement and risk analysis by establishing value functions for user data.
- Enhanced object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC).
- Completed selection of basic Information Assurance Science and Engineering Tools (IASET) architecture for incorporation into an integrated design environment.
- Conducted initial IASET experiments with information assurance design methodologies emphasizing the application of science-based metrics in assessment activities.

• Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 7.038 Million)

- Developed collection, exploitation, and dissemination synchronization techniques to link all phases of ISR management in support of the war-fighter.
- Developed Multi-Asset Synchronizer to provide near real time organization and synchronization of multiple disparate sensor assets; installed and operated system at U.S. Southern Command.
- Initial automated collection strategy tools passed to the Integrated Collection Management efforts in the Defense Intelligence Agency.

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- Control of Agent-based Systems (CoABS). ($ 15.208 Million)
  - Developed and demonstrated a flexible information infrastructure and an interoperability tool called the Agent Grid, which supported the dynamic deployment of complex applications for dynamic domains such as military command and control. These applications require the composability, adaptability, and autonomy provided by software agents interoperating in dynamic, mixed-initiative teams with human users. The Grid provides access to shared protocols and ontologies, mechanisms for describing agents' capabilities and needs, and services that support interoperability among agents at flexible levels of semantics distributed across a network infrastructure.

- Project Genoa. ($ 11.421 Million)
  - Knowledge Discovery: Transitioned a knowledge discovery tool to Intelink Management Office; developed and implemented information extraction from text and extensive use of innovative visualization of complex information relationships.
  - Structured Argumentation: Refined crisis models, developed tools for scenario based, alternative futures reasoning, and developed collaborative option generation, continued work on meeting transcription and began development ability to navigate and play back corporate memory.
  - Experimented with products from Information Assurance projects to enable a multi-intranet system to operate at mixed security levels.
  - Continued evaluation by users from the national security community.

- Active Templates. ($ 7.542 Million)
  - Developed and encoded templates of standard operating procedure, which integrated causal model capability to show how constraints, event triggering, inference, and uncertain reasoning can be utilized for fast crisis planning and execution.
  - Created a flexible networked architecture that supports template linking, dynamic connections, consistency management, and dynamic information sharing and characterized performance in terms of connection speed, message throughput, and consistency maintenance.

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(U) **FY 2001 Plans:**

- Man & Machine Command & Control (M2C2). (formerly JFACC and Dynamic Command and Control). ($ 18.252 Million)
  - Construct a dynamic, multi-faceted architectural design for military command and control systems, which provides agility and stability to military operations.
  - Develop specifications for a system context and designs for selected decision making tools based on the control theory discoveries, which enable robustness and flexibility.
  - Construct an extensive library of operational "plant" models, which can support a wide range of theoretical to operational experiments.
  - Experimentally validate the command and control architectures and design concepts produced during this phase.
  - Continue to explore new and innovative theories, techniques, and tools for agile and stable military operations.

- Information Assurance Science and Engineering Tools (IASET). ($ 21.696 Million)
  - Develop science-based security enabling disciplines, methods, and preliminary tools that will allow for the design of measurable and useful Information Assurance systems.
  - Perform seedling research and development on malicious code mitigation including incorporation of relevant IASET science and method developments.
  - Conduct a series of mini-experiments to foster the initial incorporation of developments in Information Assurance sciences, mathematics, metrics, and science-based methods into a set of design and assessment tools.
  - Use experiment results to strengthen the development of the basic architecture into an integrated environment for the design and assessment of Information Assurance.

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 9.513 Million)
  - Explore new ISR system architectures and technologies to increase effectiveness and reduce man loading in tactical as well as planning applications.
  - Conduct operational evaluation of AIM automated collection strategy development and multi-asset synchronization technologies with U.S. Southern Command and Joint Forces Command.

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- Evaluate dynamic re-planning capabilities as part of an integrated collection management demonstration.
- Conduct experimentation on Strategy Developer and Multi-Asset Synchronizer at Nellis experiment facility (NTOC).
- Characterize performance of AIM components using quantitative estimates of collection needs from real time processing and exploitation systems such as Dynamic Database (DDB).

- Control of Agent-based Systems (CoABS). ($ 12.800 Million)
  - Deploy agent technologies and tools using the agent grid for use in ACTD and JEFX activities. Empirically demonstrate efficacy of approach in these realistic military domains.

- Active Templates. ($ 10.000 Million)
  - Integrate and demonstrate multiple templates merging by users to update information, add dependencies, and attach problem-solvers.
  - Demonstrate initial capability to automatically and continuously compile geophysical information from different databases and other network information sources.

- Project Genoa. ($ 6.948 Million)
  - Complete development of corporate memory.
  - Complete development of future scenario generation tools.
  - Complete development of tailored presentation tools.
  - Develop and validate emerging concepts from collective reasoning applied to the asymmetric threat. Investigate the use of intelligent agents to automate functions where possible.
  - Demonstrate products that will permit operations in a multi-level security environment.
  - Incorporate changes resulting from client evaluation in real world asymmetric environment.

(U) **FY 2002 Plans:**

- Man & Machine Command & Control (M2C2). ($ 15.000 Million)
  - Demonstrate prototypes that exhibit control over the temporal and spatial dynamics of military operations.

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- Promote maturing technologies into new prototype tools while introducing new and innovative theories, techniques, and tools for further exploration
- Experiment with and assess prototypes at Joint and Service battle labs; transition one or two of the most promising prototypes
- Expand the system framework to accommodate a common internal information and agent management.

• Information Assurance Science and Engineering Tools (IASET). ($ 16.984 Million)
- Instantiate advances in cyber science and design/assessment methods in an initial set of tools as IA CAD.
- Initiate transition of scientific methods to other programs in the Information Assurance and Survivability (IA&S) suite.
- Perform science-based experiments to determine effectiveness of developed malicious code mitigation research and tools.

• Advanced ISR (Intelligence, Surveillance and Reconnaissance) Management (AIM). ($ 9.893 Million)
- Evaluate integrated AIM capabilities for optimized collection management to provide continuous dynamic and proactive collaboration between operations and ISR.
- Transition multi-asset synchronization and automated collection strategy development tools to airborne and overhead collection systems including classified ISR management programs.

• Control of Agent-based Systems (CoABS). ($ 8.893 Million)
- Release agent-grid code and components tailored to military user needs and evaluated in military applications.

• Active Templates. ($ 8.893 Million)
- Develop Active Template representation/library capabilities for extending the terms, critical planning parameters for template adaptation and merging.
- Demonstrate advanced tools for extending term-ontology to avoid duplication and conflicting semantics

• Project Genoa. ($ 0.989 Million)
- Transition components to user agencies such as PACOM, DIA, OSD(C3i) etc.

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- Reliable Mobile Agents for Hostile Military Environments. ($ 2.416 Million)
  - Develop mathematical models of bandwidth utilization for code mobility.
  - Develop mathematical models of computational integrity for code mobility.

(U) **FY 2003 Plans:**

- Man & Machine Command & Control (M2C2). ($ 15.000 Million)
  - Demonstrate prototypes that exhibit control over the process and organizational structure dynamics of military operations.
  - Promote maturing technologies into new prototype tools while introducing new and innovative theories, techniques, and tools for further exploration.
  - Experiment with and assess prototypes at Joint and Service command post exercises; transition one or two of the most promising prototypes.
  - Expand the system framework to accommodate connectivity to external information and agent management.

- Information Assurance Science and Engineering Tools (IASET). ($ 13.500 Million)
  - Integrate further Information Assurance (IA) tools into the Integrated Design and Assessment Environment.
  - Launch/transition science activities into the insider threat assessment community.
  - Conduct an experiment using IA CAD and the Integrated Design and Assessment Environment to provide demonstrable enhanced assurance to actual information system designs.

- Active Templates. ($ 7.000 Million)
  - Develop Active Template Planning and Execution Shell including tools for template development such as for selecting and tailoring dependencies and problem solving algorithms. These tools will also include advanced problem solvers like generative planning, temporal/uncertain reasoning, and triggering for complex events.

- Control of Agent-based Systems (CoABS). ($ 5.000 Million)
  - Develop and release agent-grid code and components generalized for broad military users and commercial standards.

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- Reliable Mobile Agents for Hostile Military Environments. ($ 6.500 Million)
  - Develop and implement mobile agent architecture standard.
  - Demonstrate resilience of computational integrity in distributed environments.
  - Fit parameters to models via empirical testing.
  - Determine security and performance requirements for deploying mobile agents into operational settings.

- Virtual Mission, Planning, and Training for Countering the Asymmetric Threat. ($ 5.000 Million)
  - Conduct experiments in training and planning via enhanced gaming software environments.

- Cyber Sensor Grid. ($ 6.234 Million)
  - Develop cyber sensor coverage theories and models to support effective placement strategies.
  - Prototype application-specific and effects-based detection methods.

- Bio-Surveillance. ($ 9.000 Million)
  - Develop models of potential biological agents.
  - Develop models of normal epidemiological phenomena.
  - Develop signal detection techniques for detecting known biological agents or anomalous events.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Jun 00	Installed Multi-Asset Synchronizer at U.S. Southern Command.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.

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Jul 00	Demonstrate Knowledge Base approach to systems management.
Jul 00	Demonstrate user data value functions.
Jul 00	Demonstrated rapid knowledge discovery and structured argumentation in crisis management.
Sep 00	Demonstrate AIM automated collection strategy development and multi-asset planning at JEFX '00.
Sep 00	Demonstrate augmented CORBASEC. Demonstrate composable trust systems.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.
Sep 00	Demonstrate semi-automated templates handling incomplete data amidst 100 execution changes in a military exercise.
Sep 00	Demonstrate Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) automated collection strategy development and multi-asset planning Joint Expeditionary Force Exercise (JEFX) '00.
Dec 00	Demonstrate tools for analysis of IW attack costs.
Dec 00	Demonstrate system recognition of malicious code.
Feb 01	Laboratory demonstration of AIM interaction with dynamic battle-space estimation capability to show tactical benefits.
Mar 01	Initiate development of selected prototype tools from new C2 architectural concepts and control strategies.
Jun 01	Demonstrate Genoa multi-enclave operations for distributed meetings using Genoa tools.
Jun 01	Demonstrate agent-grid that enables the run-time integration and interoperability of software components such as legacy applications, objects, and agents.
Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.
Jul 01	Conduct experimentation on Strategy Developer and Multi-Asset Synchronizer at Nellis experiment facility (NTOC)
Sep 01	Demonstrate prototype adaptive security system and prototype DII I&W system.
Sep 01	Demonstrate that users can tailor their own templates, update information, add dependencies, and attach problem-solvers. Show that active template technology is scalable in that 50 templates have been built. Show that planning speed doubles and plan quality improves.
Jan 02	Experimentally validate M2C2 system framework and prototype designs and concepts.
Mar 02	Test and evaluate open and closed loop performance of AIM system to coordinate collection assets in a dynamic and responsive environment.

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Jun 02	Initial application of information assurance design tools in design programs.
Sep 02	Show six-fold increase in execution replanning using Active Templates attached to live data feeds from battlefield sensors.
Oct 02	Complete solicitation and source selection process.
Dec 02	Release product quality agent-grid code and components tailored to military user needs and evaluated in military applications.
Jul 03	Release product quality agent-grid cose and generalized for broad military users and commercial standards group.
Aug 03	Integrated Design and Assessment Environment applied to design effort for new information system.
Oct 03	Conduct empirical validation experiments of mathematical computation models which include code mobility.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Information Integration Systems CCC-02	79.189	49.654	44.120	32.246	29.512	34.837	35.837	35.837	Continuing	Continuing

(U) **Mission Description:**

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future (CPOF) program, the Symbiotic Communications effort and the Bandwidth Solutions initiative.

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to tactical users at multiple echelons. More specifically, DDB ingests and registers Ground Moving Target Indicator (GMTI) radar, Signals Intelligence (SIGINT) and Imagery (Synthetic Aperture Radar, Electro-Optic and Infra-Red) Intelligence (IMINT) raw sensor data to a common fiducial to reference all sensor data to a Common Targeting Grid. A Sensor History Database (SHDB) will store and maintain the output from the Change Detectors and retain the raw sensor data as a pedigree. All-source Track and ID Fusion (ATIF) processes have been developed to establish a derived Situation History Database by filtering tactically significant changes from the Sensor History Databases. Situation Monitoring and Change Detection (SMCD) processes will fuse MTI flow densities, SIGINT emission densities and the ATIF derived situation history to derive force relationships. This objective includes the development of theory and techniques for (a) incorporating mission needs and situations into context for low-level processing algorithms, and (b) utilizing advanced phenomenology models to derive target behavior and background constraints from multi-sensor observations. Significant situation changes will be shared throughout the DDB system through a scaleable High Performance Data Server (HPDS), which connects the SHDB nodes, algorithm applications, processors, and information repositories. DDB "normalcy models" are being developed to establish conditions for change detection, to trigger external processes when conditions meet posted criteria, propagate updates/alerts across DDB processors, and support queries and searches of associated databases.

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(U) The Airborne Communications Node (ACN) program will enable an affordable, autonomous communications infrastructure that simultaneously provides assured communications, situational awareness, and signals intelligence (SIGINT). It is envisioned that ACN payloads will be integrated on platforms ranging from High Altitude Endurance (HAE) unmanned airborne platforms (e.g. Global Hawk) to tactical platforms (e.g. Predator, Army Tactical UAV). The ACN payload will be scalable such that payloads for various platforms can be constructed from a core module set. The ACN will provide wide-area wireless communications and SIGINT services over the theater of operation for joint and multinational forces by establishing an early robust airborne infrastructure for intra-theater line-of-site (LOS) and reachback beyond line-of-site (BLOS) without the need for large in-theater assets. ACN will augment and enhance the battlefield communications infrastructure in order to adapt communications, situational awareness, and SIGINT services to the flow of battle. Therefore, the ACN system needs to be adaptable, interoperable, robust, secure, and affordable within the size, weight, and power constraints of the intended platforms.

(U) The objective of the Command Post of the Future (CPOF) program is to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems required to do so. Three important command functions will be addressed in order to achieve this objective: 1) improved speed and quality of situation awareness; 2) improved speed of course of action (COA) development and selection; and 3) improved clarity of COA communication between commander and subordinates. For each of these command functions, CPOF is developing technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The key technologies to be developed are: (1) an integrated visualization environment for the commander and his staff; (2) a powerful and comprehensive human-computer interaction capability; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of systems to automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command. The program concludes at the end of FY 2002.

(U) The Symbiotic Communications program will develop a system to deliver enhanced situational awareness by exploiting the capabilities of currently fielded communications systems. The goal is to provide warfighters with precision data that can be used by existing weapon systems for accurate mapping and guidance.

(U) The Bandwidth Solutions program will focus on recent advancements in the commercial communications sector that could have a profound effect on military communications. As U.S. forces continue to be deployed into dense and urban environments and the traditional

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restriction of bandwidth limited communications continues, the need to easily communicate and overcome these traditional barriers becomes paramount. Alternative and enhanced technologies must be employed. This program will conduct demonstrations of the application of those kinds of technologies including those in the high frequency, optical, and multiple user/geolocation arenas. The ultimate goal of this program will be the infusion of these robust technologies to enhance the effectiveness of communications for U.S. forces.

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), which concluded in FY 2000, was to integrate and demonstrate information management and battlefield awareness technologies that allow operational users to easily access and exploit an expanded, massive information flow, and for commanders to manage it. The Phase III (Technology Improvement) phase of BADD, renamed the Agile Information Control Environment (AICE), developed and demonstrated breakthrough information management technologies to provide a 10 fold improvement in the efficient and timely delivery of information.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- BADD ACTD. ($ 6.541 Million)
  - Completed the integration effort with DISA's products. Fielded BADD/DISA products to selected CINCs six months prior to the end of the ACTD. Continued upgrading capability (based on warfighter input/feedback) to provide a more enhanced version to the CINCs in the latter part of the FY. Provided interfaces that will allow other ACTDs and programs to take advantage of the BADD capabilities. Upgraded the software to be compliant with the DISA next iteration of the DII COE. Transitioned capability to DISA.

- AICE. ($ 3.222 Million)
  - Completed closeout of AICE in concert with BADD ACTD transition.

- Dynamic Database (DDB). ($ 25.106 Million)
  - Completed and demonstrated the DDB architecture design in the Component Experimentation and System Integration Laboratory (CESIL).
  - Developed registration algorithms to co-register GMTI, SIGINT, and IMINT data to a Common Image Base (CIB).

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- Expanded the GMTI, SIGINT and IMINT Sensor History Database (SHDB) object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data through a scaleable High Performance Data Server (HPDS). Visible Electro-Optic (EO) data was added to the stored data-types.
- Demonstrated the ability to extract enhanced multi-sensor data features over time through the development of GMTI, SIGINT and IMINT Change Detection processes Experiments with fusing image and object level Change Detectors for Synthetic Aperature Radar (SAR) and Electro-optic (EO) has resulted in a dramatic reduction in false alarms, which in turn improved the cueing and timeliness of object identification GMTI Change Detection experiments using multiple platforms showed increased track continuity and location accuracy. SIGINT Change Detection experiments showed capability to leverage emission density and emission profiles (normalcy models) over large areas for detecting military emitters.
- Developed and validated "normalcy models" of GMTI, SIGINT and IMINT data over time. These normalcy models are used to set thresholds in remote sensor "trip wires" at selected locations in the battlespace. Increased activity in one or more of the sensor types will trigger DDB to invoke algorithms for additional processing and cue operators to perform analysis of situation.
- Developed All-source Track and ID Fusion algorithms that demonstrated the ability to track objects through move-stop-move cycles.
- Developed a DDB system model to quantify performance expectations based on sensor/algorithm dependencies.
- Demonstrated an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the SHDB, and provides the user ready access to GMTI, SIGINT, EO, IR, and SAR sensor history data co-registered to a common fiducial and entity-level situation hypotheses.

• Command Post of the Future (CPOF). ($ 13.878 Million)
  - Produced technology in the areas of automated visualization, multi-modal interaction (speech and gesture recognition) automated context tracking, dialog management, and cognitive modeling.
  - Cognitive visualization principles were encoded in a knowledge base and the tools for extracting and using these principles were developed.
  - Tools for recognizing speech and 2D gesture interactions were developed as well as higher order sketch understanding.
  - Automated context tracking encoded the mental models captured in the CPOF commander's dialog system and developed technologies for isolating and tracking cues for indexing the CPOF commander's dialog system.

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- Completed the first series of limited objective experiments (LOEs) and conducted a comprehensive experiment in conjunction with a warfighting experiment.
- Phase II experiments were designed and a number of the phase II LOEs were run.
- The integration environment was completed and individual technology components were added.

• Airborne Communications Node (ACN). ($ 30.442 Million)
- Down selected two teams for technology enabling payload architecture and development. This architecture will be targeted to operate within the stringent environment of the unmanned aerial vehicles, thereby stressing the packaging technology required to meet the form, fit and function. The payload architecture is modular and scalable, enabling subsets of the full functionality to be transferred to other SWAP-limited platforms.
- Conducted laboratory demonstrations of critical subsystems (e.g., interference mitigation subsystem).
- Assessed ACN capability for enhancing battlefield situational awareness.

(U) **FY 2001 Plans:**

• Dynamic Database (DDB). ($ 12.240 Million)
- Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities.
- Complete algorithm development to use nonlinear techniques for automatic recognition of speakers and parameter characterization of emitters, derivation of tactical communications networks from communications emissions, recognition of new/different vehicular behavior from GMTI, and near real time extraction of military objects from multi-spectral imagery.
- Complete initial capability for object discovery of large numbers of tactically significant ground targets (moving and stationary) over a brigade size area. This capability is achieved by an All-source Track and Identification Fusion (ATIF) algorithm, which automatically builds and maintains position, kinematic and ID features. ATIF unique capability to track targets through multiple move-stop-move cycles will be demonstrated.
- Demonstrate an interactive Dynamic Database (DDB) system-level capability that performs multi-sensor object level fusion.
- Initiate development of group tracking capability where groups are defined by behavioral or functional activity.

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- Incorporate DDB technology into a transportable testbed version of the XVIII Airborne Corps, 525th Military Intelligence Brigade, Tactical Exploitation System and conduct experiments in a field environment.
- Conduct experiments to manage sensor collection with information needs derived from ATIF and supporting fusion algorithms to reduce uncertainty and ambiguity about objects for improved tracking and identification.

• Command Post of the Future (CPOF). ($ 24.861 Million)
  - Continue to develop and integrate new CPOF technology into a complete CPOF commander's dialog system to enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react.
  - Integrate and test new versions of the technology components in a series of simulation-based decision experiments.
  - Integrate the most effective technology into a complete CPOF commander's dialog system for an end-to-end demonstration in a simulated joint exercise.
  - Begin preparations for an operational demonstration of the CPOF commander's dialog system in a joint field exercise in FY 2002.
  - Extend CPOF technology to include 3D gesture, 2D and 3D audio and haptic interface capabilities.

• Airborne Communications Node (ACN). ($ 12.553 Million)
  - Complete development of critical technologies.
  - Verify the critical technologies at the component level.
  - Mature the ACN architecture to a preliminary design.
  - Initiate development of signal processing algorithms to exploit ACN for situational awareness.
  - Conduct "rooftop" measurements to validate situational awareness concepts.

(U) **FY 2002 Plans:**

• Airborne Communications Node (ACN). ($ 10.000 Million)
  - Verify the system design through simulation.
  - Mature the architecture to a critical design.
  - Transition system to services.

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- Bandwidth Solutions. ($ 2.500 Million)
  - Demonstrate robust communication system technologies that take advantage of the benefits of operating in high frequencies and with optical technology.

- Symbiotic Communications. ($ 4.749 Million)
  - Conduct flight tests with non-real time system to validate algorithms.
  - Complete development of processing algorithms.
  - Investigate potential platforms and begin hardware optimization process.

- Command Post of the Future (CPOF). ($ 11.871 Million)
  - Complete the final series of experiments in cognitive principals of visualization, multi-modal interaction, dialog management and command decision making.
  - Complete technology development of CPOF component technologies of dynamic visualization, multi-modal interfaces, and dialog management.
  - Integrate final component technologies and knowledge bases into the final prototype commander's dialog system and qualify system capabilities.
  - Participate in an advanced warfighting experiment using the CPOF commander's dialog system as the primary command interface of the brigade and battalion level.
  - Transition and integrate the CPOF commander's dialog system into the Global Command and Control System (GCCS), the DARPA/Army Future Combat System (FCS), and the Army's Command Post XXI Test Bed.

- Dynamic Database (DDB). ($ 15.000 Million)
  - Characterize performance and demonstrate system level capability for object discovery, which incorporates feedback and interaction among all Dynamic Database (DDB) components.
  - Expand object discovery capability by ingesting and co-registering data from new tactical sensing regimes, e.g., biological, chemical, magnetic, acoustic, video and seismic unattended ground sensors (UGS) along with remote sensing provided by conventional intelligence collectors.

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- Conduct data collection to incorporate all sensing regimes under difficult conditions to support experimental goals and algorithm development. Leverage transportable testbed for collection purposes and to gain user feedback.
- Expand algorithm performance to address varying terrain and difficult operating conditions such as high obscuration, close spacing, high density, and deception. Develop terrain intensification techniques for discovery of tactically significant obstacles and land features as well as context for estimating trafficability and identifying regions of interest.
- Develop models of force relationships derived from own force reports, doctrinal and sensed information, and knowledge of the environment.
- Develop metrics for valuation of information content, collection cost functions, and related objective function candidates in a control loop paradigm.

(U) **<u>FY 2003 Plans:</u>**

• Symbiotic Communications. ($ 7.246 Million)
- Develop passive, rapid terrain characterization for preparation of the battlefield.
- Complete data processing architecture.
- Initiate build of optimized airborne system.

• Bandwidth Solutions. ($ 10.000 Million)
- Enhance detection and geolocation of emitters in a dense and cluttered environment.

• Dynamic Database (DDB). ($ 15.000 Million)
- Develop registration and modeling processes to enable and incorporate fusion of Human Intelligence (HUMINT) (e.g. FBCB2, scouts, forward observers) information with sensed information. Expand multi-hypothesis algorithms to exploit uniqueness and limitations inherent in HUMINT.
- Initiate design and conduct experiments of automated techniques for force structure analysis and situation estimation driven by named areas of interest and priority target types. These experiments will extend object discovery performance by leveraging group tracking capability, and establishing relationships among objects, groups, and the environment. Algorithms will be designed with users elevated to the role of supervisors; in this capacity users provide mission goals, monitor automated processes considered to be routine,

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and focus attention on unusual or difficult object and group activity. Benefits will be measured in terms of more timely response and improved awareness of activity over wider areas.

– Conduct field experiment of closed loop DDB and Advanced Intelligence, Surveillance, and Reconnaissance Management (AIM) technology to characterize dynamic control performance in maintaining object discovery over a brigade size area for large numbers of targets.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Dynamic Database:	
Feb 01	Characterize performance of DDB capability to provide information needs for use in Advanced Intelligence, Surveillance, and Reconnaissance Management (AIM) to drive sensor collection.
Jun 01	Demonstrate an interactive DDB system that ingests raw multi-sensor data, aligns, mosaics and displays the data within a 3-D Spatio-temporal reference frame in the System Integration Laboratory (SIL).
Sep 01	Demonstrate the insertion of DDB technology in a transportable testbed version of the XVIII Airborne Corps, 525th Military Intelligence Brigade, Tactical Exploitation System.
Jan 02	Conduct DDB data collection, utilizing transportable testbed, to explore additional sensing regimes under difficult conditions.
Mar 02	Complete study of metrics for valuation of DDB derived information content and collection cost functions.
Jul 02	Demonstrate DDB system level capability for object discovery incorporating new sensing regimes and component feedback.
Dec 02	Conduct field experiment of closed loop DDB and AIM technology

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Battlefield Awareness And Data Dissemination:
Sep 00 Complete BADD ACTD transition to DISA and the Services.

Agile Information Control Environment:
Sep 00 Demonstrate AICE prototype MetaNet.

Airborne Communications Node:
Jan 01 Interim review and initial laboratory test data.
Sep 01 System performance review and simulation test results.
Dec 01 System design review incorporating integration plan and physical architecture allocation.
Jan 02 Critical Design Review.

Command Post Of The Future:
Oct 00 CPOF Comprehensive Experiment One run in conjunction with Advanced Warfighting Experiment (AWE).
Sep 01 CPOF Comprehensive Experiment Two to run at Fort Hood in warfighting experiment.
Mar 02 Demonstrate Course of Action (COA) level analysis within major Army exercises (e.g., Advanced Warfighter Experiment - AWE).

Symbiotic Communications:
Feb 02 Validate range apodization approach.
Jun 02 Initial flight test.
Dec 02 Critical Design Review for airborne system.
Jul 03 Complete automated characterization algorithm

Bandwidth Solutions:
Feb 03 Complete technology trade studies.
Aug 03 Complete initial architectural flow down.

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COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	173.945	182.225	188.424	200.482	249.396	278.596	296.896	301.896	Continuing	Continuing
Guidance Technology SGT-01	19.301	22.173	22.199	23.964	43.514	46.564	46.564	46.564	Continuing	Continuing
Aerospace Surveillance Technology SGT-02	41.713	61.545	78.838	88.232	90.550	100.000	109.300	109.300	Continuing	Continuing
Air Defense Initiative SGT-03	36.340	24.301	14.667	15.000	22.750	39.200	48.200	53.200	Continuing	Continuing
Sensors and Exploitation Systems SGT-04	76.591	74.206	72.720	73.286	92.582	92.832	92.832	92.832	Continuing	Continuing

(U) **Mission Description:**

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

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(U) The Air Defense Initiative is an on-going project whose overall goal is to counter advanced battlefield threats and enhance the survivability of U.S. assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; provide near-real-time semi-automatic exploitation of wide-area moderate resolution imagery data; provide real-time and accurate battlefield assessment and semi-automated precise and reliable target recognition and targeting of critical moving targets.

(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	177.598	182.225	203.424	229.482
Current Budget	173.945	182.225	188.424	200.482

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects minor program repricings and SBIR reprogramming..
FY 2002 Decrease reflects the program completion of LCCMD and Airborne Video Surveillance.
FY 2003 Decrease reflects the program completion of the MEM-tenna and Force Protection – Ground Moving Target Identification programs.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Guidance Technology SGT-01	19.301	22.173	22.199	23.964	43.514	46.564	46.564	46.564	Continuing	Continuing

(U) **Mission Description:**

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the ability of GPS users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all-solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. The Phase 2 was structured and continues as a competitive program with two prime contractors.

(U) The GGP program also will increase the ability of GPS users to operate effectively in the presence of enemy jamming or countermeasures (Global Positioning Experiments – GPX). It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability

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of GPS signals to users in the presence of enemy jamming. The considerably increased transmit power of the APL fights off the effects of jamming on DoD receivers. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The project assesses three key challenges. First, it will demonstrate non-Keplerian orbit predictions of the APL and show that only software modifications are needed for GPS user receivers. Second, the APL must also accurately navigate using GPS satellites in the presence of jamming. Accordingly, this project provides for the design, development and demonstration of a low cost, space-time adaptive beamforming anti-jam receive antenna and a digital adaptive beamformer. With advanced algorithms, this will support greater than 45 dB nulls against up to six different jammers. Third, it is necessary to control the desired area coverage of APL transmissions. This will require demonstration of an advanced beam shaping transmitter antenna, precise management of the radiated power and the associated command and control structure.

(U) The Microelectromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field. Three prime contractors are proceeding in Phase 2.

(U) The Advanced Navigation System Technology (ANST) program integrates a MEMS inertial measurement unit with an advanced, digital GPS receiver to achieve ultra-fast acquisition, providing a robust navigation solution in jamming and multipath environment, and enabling military operations requiring rapid turn-on. This extremely small, lightweight, low power (2-4 watts) integrated navigation system will use the latest in electronics technologies and signal processing to facilitate rapid GPS signal acquisition and high antijam performance. A good tactical grade (0.1 – 1.0 degrees per hour) MEMS inertial sensor suite will be developed and integrated to provide a coast through inertial solution during GPS signal blockage. This flexible navigation system will be software reconfigurable to support any GPS signal changes or signal opportunities as they become available. Specifically, the addition of the new M-Code signal and a new civil frequency will be supportable via software upgrades. The initial phase will integrate a brassboard MEMS INS/GPS receiver to demonstrate advanced navigation technologies and capabilities.

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(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution of near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter-collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate in real-time the distributed multi-platform emitter collections using existing or planned tactical radios with advanced network management and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self-contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- GPS Guidance Package (GGP) Global Positioning Experiments (GPX). ($ 3.865 Million)
  - Completed integration of GGP and field demonstrations.
  - Demonstrated ability of airborne pseudolites to provide high quality navigation data to GPS users during jamming.
  - Conducted laboratory demonstration of adaptive signal processing and digital beamformer for pseudolite anti-jam capability.

- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 7.525 Million)
  - Began MEMS INS integration with navigation software to demonstrate IMU operation.

- Advanced Tactical Targeting Technology. ($ 7.911 Million)
  - Completed Advanced Tactical Targeting critical design and began fabrication.

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(U) **FY 2001 Plans:**

- Global Positioning Experiments (GPX). ($ 3.970 Million)
  - Complete development and evaluation of elements of the pseudolite network.
  - Initiate integrated demonstration using a single airborne pseudolite with integrated digital adaptive beamforming antenna.
- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 5.955 Million)
  - Delivery of MEMS inertial measurement unit to the Government.
- Advanced Tactical Targeting Technology. ($ 12.248 Million)
  - Complete fabrication and ground tests.

(U) **FY 2002 Plans:**

- Global Positioning Experiments (GPX). ($ 5.443 Million)
  - Complete demonstration with a captive carried weapon in a GPS jamming environment.
- Microelectromechanical Sensor Inertial Navigation System (MEMS INS). ($ 2.979 Million)
  - Complete field demonstration of MEMS INS navigation capabilities.
- Advanced Navigation System Technology (ANST). ($ 3.000 Million)
  - Design the ANST brassboard, which would integrate a MEMS IMU with an advanced GPS receiver.
- Advanced Tactical Targeting Technology. ($ 10.777 Million)
  - Complete flight test.

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(U) **FY 2003 Plans:**

- Global Positioning Experiments (GPX). ($ 10.400 Million)
  - Demonstrate successful weapons guidance with a GPS jamming environment using multiple airborne pseudolites.
- Advanced Navigation System Technology (ANST). ($ 8.000 Million)
  - Complete brassboard design and initiate fabrication.
- Advanced Tactical Targeting Technology. ($ 5.564 Million)
  - Complete data analysis.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sep 00	Deliver GPS Guidance Package (GGP) units to the Government.
Oct 00	Complete laboratory test of digital adaptive beamformer.
Jun 01	Complete evaluation of pseudolite elements.
Jul 01	Deliver GGP units to the Government (second source).
Sep 01	Complete AT3 ground tests.
Feb 02	Complete laboratory demonstration of MEMS INS operations.
Jun 02	Complete field test/demonstration of MEMS IMU.
Jul 02	Demonstrate integrated Pseudolite System with captive carry weapons.
Aug 02	Complete AT3 flight test.
Sep 02	Complete ANST design.

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Jun 03	Demonstrate integrated Pseudolite System with live fire weapons in jamming environments.
Jun 03	Begin fabrication/integration of the ANST components.
Jul 03	Complete AT3 data analysis.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Aerospace Surveillance Technology SGT-02	41.713	61.545	78.838	88.232	90.550	100.000	109.300	109.300	Continuing	Continuing

(U) **Mission Description:**

(U) This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance and targeting systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The DARPA Digital Radio Frequency Tags program will develop a flexible, potentially low cost technology to allow radars (Moving Target Indicator (MTI) and Synthetic Aperture Radar (SAR)) to receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Additionally, the Digital RF Tag architecture can be exploited for other missions, with the net effect of substantially enhancing U.S. situational awareness and combat identification advantages.

(U) The goal of the Adaptive Spectral Reconnaissance Program (ASRP) is to build the technical underpinnings for future multispectral and hyperspectral systems to counter camouflaged and concealed surface targets. The program is jointly funded with the Army (CECOM). ASRP will develop the technologies for real-time detection of tactical targets employing concealment, camouflage, and deception (CC&D) using hyperspectral sensor data to cue high resolution, geo-located, target imagery. Algorithms, models, and phenomenology databases will be developed for use primarily in the visible through near infrared (VNIR) and short wave infrared (SWIR) bands to provide daytime capability, while the Army will focus on development of advanced long wave infrared (LWIR) sensor technology that will eventually enable nighttime capability. ASRP will employ an airborne testbed to validate the technology elements being developed and the overall technical concept of a real-time hyperspectral technology-based tactical directed area search capability. ASRP will leave behind validated performance prediction tools, specifications for

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validated robust low false alarm rate target detection algorithms, a real-time processor system, validated target detection in the VNIR/SWIR, and a database of targets and backgrounds.

(U) The Discoverer II program is a DARPA, Air Force, and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance, and precision geo-location support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the Defense Science Board (DSB) Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to meet warfighter needs at lower cost, and to enhance system maturity thereby facilitating a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology R&D demonstration program. In the first phase, industry will conduct detailed trade studies necessary to define both an affordable objective space-based radar system for the 2010 timeframe and a demonstrator system for the 2005 timeframe that shows that it addresses the highest risks of the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the risk reduction efforts will be exploited to ensure Discoverer II R&D demonstration can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode GMTI/SAR space-qualified electronically scanned antenna; 2) developing low power Microelectromechanical Systems (MEMS) for scanning radar modules (10x reduced power requirement); and 3) sparse band processing for data compression allowing on-ground processing with moderate rate communications links, and Automatic Target Recognition (ATR) quality range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and precision guided munitions (PGM) targeting (precision geolocation accuracy theater wide). If industry trade studies, supported by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, Phase II will build and fly two GMTI/SAR technology demonstration satellites. The R&D demonstration will validate the operational utility and technical feasibility of advanced C4ISR capability complementing/extending current Unmanned Air Vehicle (UAV)/Aircraft architectures. The demonstration will show how an objective system can provide deep-look access to denied areas, and near continuous coverage from diverse look angles over the battlefield. Objectives for the demonstration include mobile target detection, tracking, and targeting; intelligence preparation of the battlefield; wide area search, and precision

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engagement with direct downlink to the warfighter. The Discoverer II demonstration program will allow the joint community to make an informed decision on future operational Space Based Radar after the FY 2005 flight demonstration.

(U) The Novel Antennas Program is developing techniques to produce small, lightweight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures are being explored.

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of strategic functions, including command and control and weapons of mass destruction associated activities. The Counter-Underground Facilities program (CUGF) will develop technologies to characterize UGFs: identification of facility function, UGF pace of activity, pre-attack status of the facility, trans-attack activities, and post-attack status. Techniques will be developed to determine locations of critical systems (power, water, airflow vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack. Additionally, techniques will be developed for effluent detection and monitoring. Candidate technologies include, but are not limited to, low frequency electromagnetics, multi/hyperspectral imaging, seismic imaging, and coherent passive seismic, acoustic and electromagnetic monitoring.

(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or satellite pulse Continuous Wave (CW) radar to detect, locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The RotoSAR program will develop revolutionary sensing capability by installing a synthetic aperture radar (SAR) into the rotor blades of a new class of Helo with large area wings. This new generation of high endurance rotorcraft will be introduced into the battlefield as surveillance platforms. The dynamics of helicopter blades enables a SAR Image, improving performance over a conventional radar system. Under this program,

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techniques will be developed to compensate for blade motion in SAR postprocessing, transmit high bandwidth signals along the length of the blade, and integrate the electronic antenna components with the structural blade materials in an affordable manner. The presence of RotoSAR on an unmanned surveillance rotorcraft will provide an imaging capability for immediate support of the battlefield commander.

(U) The Large Millimeter Wave Telescope (LMT) program is developing the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) **Program Accomplishments and Plans:**

(U) **FY2000 Accomplishments:**

- Radio Frequency (RF) Tags. ($ 7.728 Million)
  - Completed a Preliminary Design Review (PDR) for a digital RF Tag, system level trade study, and technology insertion plan, and selected two approaches for continued development.
  - Initiated advanced development of data encoding and extraction algorithms.

- Adaptive Spectral Reconnaissance. ($ 3.978 Million)
  - Completed visible through near infrared (VNIR)/short wave infrared (SWIR) algorithm development, including implementation of new algorithms and hybrid fusion techniques.
  - Completed VNIR/SWIR data collection, analysis and validation activities, including collects at Ft. A.P. Hill and Aberdeen Proving Grounds.
  - Completed validation of end-to-end (VNIR)/(SWIR) spectral model including real/synthetic imagery generation, atmospheric/path radiance components, sensor models, platform dynamics, and algorithm segments.
  - Completed spectral target and background signature database and released for distribution.

- Discoverer II. ($ 12.900 Million)
  - Completed Phase I satellite design efforts with two system integration (SI) contractor teams. Successfully completed second Interim Evaluation Review (IER) and will complete IER-3 culminating in preliminary designs for demonstration satellites in Sep 00.

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- Completed mission utility analyses and concept of operations studies.
- Built and tested sub-scale radar antenna designs, advanced signal processors, and exploitation software.
- Flew radar payload simulator on airborne asset and collected and analyzed data.
- Awarded Phase 1B option to two most competitive System Integrators.
- Completing Plan for Phase II Request for Proposals for anticipated Source Selection in mid FY 2001.

- Novel Antennas. ($ 2.167 Million)
  - Initiated analysis of next generation geolocation techniques technology for ground based communications exploitation.

- Counter-Underground Facilities. ($ 11.440 Million)
  - Initiated robust modeling of seismic-acoustic-electromagnetic and effluent signatures and backgrounds.
  - Planned and coordinated access for field measurements to verify phenomenology, validate models and explore sensor deployment concepts.
  - Initiated engineering descriptions of operational sites and their surrounding environments to support model validation and robustness evaluation of system concepts within operational contexts.
  - Initiated evaluation of concepts for active seismic underground facilities characterization and battle damage assessment with models and field experiments.
  - Initiated innovative technology and concept development activities.

- Underground Facilities Detection. ($ 1.500 Million)
  - Initiated and evaluated activities and technologies to improve underground facilities detection capabilities.

- Large Millimeter Telescope. ($ 2.000 Million)
  - Initiated pointing system control design.
  - Initiated full-system pointing error budget.

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(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags. ($ 7.211 Million)
  - Complete Critical Design Review (CDR) for digital RF tag.
  - Conduct component risk reduction tests on brass-board system.

- Discoverer II. ($ 40.107 Million)
  - Conduct Phase II source selection.
  - Begin performance of Phase II: System integration (SI) contractor will complete detailed design of ground moving target indicator (GMTI) radar demonstrator system.
  - Conduct Delta Preliminary Design Review (PDR).
  - Initiate procurement of long-lead items for two GMTI/ synthetic aperture radar (SAR) demonstration satellites.
  - Continue on-going signal processing and target tracking algorithm development.
  - Continue software demonstrations.
  - Conduct simulation/emulation for performance prediction, system design, etc.

- Counter-Underground Facilities. ($ 6.948 Million)
  - Complete passive seismic, acoustic, electromagnetic, and effluents modeling of signatures and backgrounds; initiate validation.
  - Initiate concept development and design of prototypes for selected technologies.

- Non-Linear Radar Communications Mapper. ($ 7.279 Million)
  - Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camouflage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development.

(U) **FY 2002 Plans:**

- Radio Frequency (RF) Tags. ($ 4.946 Million)
  - Complete tag prototype units.
  - Conduct laboratory device tests.

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- Discoverer II. ($ 55.579 Million)
  - Conduct Payload Critical Design Review (CDR).
  - Conduct System CDR.
  - Initiate Payload and Bus Manufacture Integration and Test for two satellites.
  - Conduct Ground Segment CDR.
  - Software development for Space and Ground Segments.
  - Continue simulation/emulation for performance prediction, system design, etc.

- Counter-Underground Facilities. ($ 4.946 Million)
  - Complete model validation on various types of signatures and background identifiers.
  - Complete prototype designs and initiate fabrication on selected promising technologies.

- RotoSAR. ($ 13.367 Million)
  - Perform analysis of postprocessing requirements for blade motion compensation.
  - Identify candidate platform for installation and initiate system concept development.
  - Begin electronically steerable array module development.
  - Perform electromagnetic modeling of antenna/airframe interaction.

(U) **FY 2003 Plans:**

- Radio Frequency (RF) Tags. ($ 4.000 Million)
  - Conduct airborne field tests and user demonstration.

- Discoverer II. ($ 44.846 Million)
  - Complete payload and bus manufacture integration and test for two satellites.
  - Begin payload and bus system integration and test for two satellites.
  - Continue software development.
  - Develop Tactics, Techniques, and Procedures (TTPs).

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- Continue software development for space and ground segments.
- Continue simulation/emulation for performance prediction, development of TTPs, etc.

• Counter-Underground Facilities. ($ 6.700 Million)
- Complete fabrication and initiate field demonstrations.

• RotoSAR. ($ 32.686 Million)
- Perform software development of beamforming algorithms.
- Produce prototype antenna modules.
- Fabricate blade structure and perform dynamic testing with surrogate antenna modules.
- Complete avionics design.

(U) **<u>Other Program Funding Summary Cost:</u>** *(In Millions)*

Adaptive Spectral Reconnaissance:				
Source	FY 2000	FY 2001	FY 2002	FY 2003
Army	4.000	1.900	0.000	0.000

Discoverer II:				
Source	FY 2000	FY 2001	FY 2002	FY 2003
NRO	13.330	34.700	52.600	57.023
Air Force	13.170	54.240	50.016	37.608

(U) **<u>Schedule Profile:</u>**

Plan	Milestones
Radio Frequency (RF) Tags:	
Dec 00	Conduct Critical Design Review (CDR) for digital RF Tag.

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Jan 02 Brassboard digital tag.
Mar 03 Prototype digital tag.
Jun 03 Airborne field test of prototype tag.

Adaptive Spectral Reconnaissance:
Dec 00 Complete validated visible through near infrared (VNIR)/short wave infrared (SWIR) model and tools.
Dec 00 Deliver VNIR/SWIR algorithm specifications (including detection, fusion and recognition).
Dec 00 Complete VNIR/SWIR data analysis and deliver phenomenology databases.

Discoverer II:
Aug 00 Interim Evaluation Review (IER) #3.
Oct 00 Phase II RFP release.
Apr 01 Award Phase II System Integrator (SI) contract for detailed design of the demonstration system.
Jun 01 Delta-Preliminary Design Review with SI.
Mar 02 Payload Critical Design Review (CDR).
Jun 02 System Critical Design Review (CDR).
Sep 03 Complete Payload 1 Manfacture Integration and Test.

Novel Antennas:
Jul 00 Wideband link demonstration.
Sep 00 Transition.

Counter-Underground Facilities:
Nov 00 Initiate model validation experiments.
Jul 02 Complete model validation experiments and selected prototype designs.
Jul 03 Complete selected prototype fabrication and initiate demonstrations.

Non-Linear Radar Communications Mapper Program:
Aug 01 Complete initial assessment of non-linear scattering of communications equipment.

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RotoSAR Program:

Oct 01	Initiate postprocessing requirements analysis and electronically steerable array module development.
Apr 02	Complete postprocessing requirements analysis.
May 02	Initiate blade structure fabrication.
May 02	Avionics preliminary design review.
Sep 02	Avionics critical design review.
Dec 02	Complete blade structural static testing.
Mar 03	Complete blade dynamic testing with surrogate antenna modules.
Apr 03	Complete antenna module breadboard.
Sep 03	Complete antenna module brassboard.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	36.340	24.301	14.667	15.000	22.750	39.200	48.200	53.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These technology developments are embodied in the Multi-Mode Laser (MML), Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM), Low-Cost Cruise Missile Defense (LCCMD), Adjunct Airborne Early Warning (Global Eye), and Microelectromechanical (MEM) antenna (MEM-tenna) programs.

(U) Reliable, robust, air-to-ground non-cooperative target combat identification (NCTID) is critically needed to extend and maintain U.S. air power dominance against surface targets. The Multi-Mode Laser (MML) program will develop and demonstrate a prototype capability for a full 4-D (3-D imaging and micro-Doppler) target identification laser radar. This system will be capable of standoff air-to-ground identification, battle damage assessment (BDA), and air-to-air NCTID. In addition to the full 4-D imaging, the program will explore a laser chemical sensing mode for enhanced target detection, identification and BDA.

(U) The SAR ECCM program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The LCCMD program will design, develop, demonstrate, and transition an affordable seeker for use on a missile interceptor system to defeat raids of unsophisticated air vehicles. Unsophisticated air vehicles are affordable, can be procured in large numbers to overwhelm U.S. defenses, and provide a credible long-term threat to both civilian population centers and military targets. The LCCMD program will conduct analyses, laboratory testing, field-testing, and captive flight-testing to select the most promising missile seeker to transition to the Military Services. The program has pursued six novel seeker concepts and is presently focused on the maturation and demonstration of an all-weather radar seeker solution.

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(U) The Global Eye (Adjunct Airborne Early Warning) program is developing the critical phased array antenna technologies and radar mode control concepts required for the introduction of multi-aperture, multi-function radar systems in UAVs. A UAV outfitted with this capability could provide lower cost (factor of 20), continuous air and ground surveillance of low intensity areas such as no-fly zones and peacekeeping areas. Such capability could supplement traditional AWACS and E-2C, and reduce the requirement to forward base large numbers of manned aircraft for these purposes. This program will also show the ability to get an order of magnitude more ground coverage in a GMTI mode through the use of multiple simultaneous receive beams in addition to the ability to support advanced ECCM techniques. The key technologies to be used are: MEMS filters for simultaneous transmit and receive and polarization diversity, high efficiency solid-state transmitters, composite lightweight integrated antennas, and advanced mode control/interleaving algorithms. Concepts will be explored which use common components to perform both the AEW mission (at the reduced ranges appropriate to this concept), and air-to-ground modes.

(U) The MEM-tenna program is developing ultra-low cost, lightweight phased array antenna technologies based on MEMS phase shifters and RF beam control through optical projection techniques. MEMS technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs field effect transistor (FET) phase shifters, while also having low insertion losses. Hard-wired beam steering control and RF manifolds are replaced by optical and RF space-fed configurations. Using these technologies, very large-scale electronically scanned arrays (ESAs) can be developed for airborne, ship and space-based applications. Optically controlled phase shifter designs incorporating MEMS technology are being developed, and these will be incorporated into a prototype ESA having 10,000 antenna elements, operating at X-band.

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 2000 Accomplishments:</u>**

- SAR ECCM. ($ 8.178 Million)
  - The design and implementation of the selected ECCM techniques was completed and demonstrated in a series of final technique demonstrations. These demonstrated techniques have begun transition into selected operational platforms to mitigate the rising proliferation of inexpensive modern threat systems. The SAR ECCM program was integrated into the annual Expeditionary Force Exercise.

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- LCCMD. ($ 16.859 Million).
  - During FY 2000, the program pursued the development and test of a LADAR Seeker, a Microelectromechanical (MEMS) Electronically Scanned Array (ESA) Radar Seeker, and a Noise Radar Seeker. The Laser Radar (LADAR) Seeker contractor upgraded the LADAR to operate at an eye-safe frequency and redesigned the receiver to provide a longer-range acquisition capability. The upgraded LADAR seeker was ground tested to demonstrate performance levels against tactical-like targets. The MEMS ESA Seeker contractor fabricated and tested an antenna sub array. Problems identified with the transmit/receive units and phase shifters during the testing were characterized and a corrective plan was initiated. The Noise Radar Seeker contractor completed fabrication and integration of hardware for a flight-worthy seeker system. The Noise Radar Seeker contractor completed seeker chamber testing. The LCCMD program down selected to an all-weather radar solution and the LADAR development was not continued beyond ground testing.

- Global Eye. ($ 3.245 Million)
  - Initiated prototype antenna designs.
  - Initiated mode control/interleaving algorithm development.
  - Initiated the design of MEMS based filters required for the use of simultaneous transmit and receive (STAR) waveforms.

- MEM-tenna. ($ 8.058 Million)
  - Initiated the design of a prototype ESA that will incorporate optically controlled X-band MEMS phase shifters, along with the design of the integrated phase shifter and optical controller modules.
  - Finalized existing designs of MEMS X-band phase shifters and initiated prototype manufacturing to demonstrate the ability to achieve the cost and reliability goals.

(U) **FY 2001 Plans:**

- LCCMD. ($ 13.474 Million)
  - The MEMS ESA Seeker contractor will complete a Critical Design Review for a flight worthy seeker system. The MEMS ESA antenna slat will be tested and multiple slats will be fabricated in preparation for a full antenna test. The Noise Radar Seeker contractor will complete field-testing and captive flight-testing. The Noise Radar Seeker real-time processor test will be initiated.

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- Global Eye. ($ 3.474 Million)
  - Initiate the fabrication of MEMS based filters to permit the use of simultaneous transmit and receive (STAR) waveforms.
  - Prototype sub array fabrication and test will begin.

- MEM-tenna. ($ 6.353 Million)
  - Manufacture of the 11,000 MEMS X-band phase shifters with optical controllers will begin.
  - Array calibration techniques with both specific and general applicability will be developed.
  - Start fabrication of the sub-scale array.

- Advanced Sensing Alternatives. ($ 1.000 Million)
  - Explore advanced sensing modalities to solve stressing combat ID and countermeasure challenges, including, but not limited to, polarization diversity and unconventional operating frequencies.

(U) **FY 2002 Plans:**

- LCCMD. ($ 2.000 Million).
  - The MEMS ESA Seeker contractor will complete the full antenna test. The Noise Radar Seeker real-time processor test will be completed.

- Global Eye. ($ 2.900 Million)
  - Insert the MEMS filters into the prototype array and evaluate its ability to support multiple-mode operation.
  - Populate an active ESA with a sufficient number of modules and filters to demonstrate multi-mode radar compatibility with full STAR waveform transmit capability.

- MEM-tenna. ($ 3.767 Million)
  - Complete the fabrication of the sub-scale array and perform proof-of-concept testing.
  - Start planning for test and demonstration of the sub-scale array to take place in FY 2003.
  - Evaluate remote array calibration techniques using sub-scale array.

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- Multi-Mode Laser. ($ 6.000 Million)
  - Initiate Design of Ground-Based Experiment for Critical Technology and Phenomenology Evaluation.
  - Conduct PDR/CDR for ground experiments.
  - Initiate design of airborne experiments.

(U) **FY 2003 Plans:**

- MEM-tenna. ($ 0.900 Million)
  - Conduct "operational" testing of the sub-scale array.
  - Demonstrate the ability to conduct remote array calibration in an operational environment.

- Multi-Mode Laser. ($ 14.100 Million)
  - Conduct ground-based and airborne experiments.
  - Initiate design of prototype demonstration system.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
LCCMD:	
Oct 00	Start Noise Radar Seeker Field Test.
Jan 01	Start Noise Radar Seeker Captive Flight Test.
Mar 01	Start MEMS ESA Seeker Slat Test.
Jun 01	MEMS ESA Critical Design Review.
Jul 01	Start Noise Radar Seeker Real-Time Processor Test.

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Oct 01 Start MEMS ESA Seeker Antenna Test.

SAR ECCM:
Aug 00 Final field ECCM Demonstration.

Global Eye:
Jul 00 Initiate MEMS filter designs.
Aug 01 Complete basic sub-array fabrication and begin testing.
Nov 01 MEMS filter insertion.
Mar 02 Begin population of active ESA for proof-of-concept demonstration.
Jun 02 Multiple-mode demonstration.

MEM-tenna:
Nov 00 Begin production of 11,000 integrated MEMS phase shifter optical controller modules.
Dec 01 Begin fabrication of sub-scale array.
Jun 02 Begin sub-scale array testing.
Aug 02 Conduct remote array calibration testing.
Mar 03 Start "operational" testing of sub-scale array and demonstrate ability to perform array calibration.

Multi-Mode Laser :
Jan 02 Initiate performance modeling effort.
Jan 02 Initiate design of ground-based experiment for critical technology and phenomenology evaluation.
Jun 02 Ground-based experiment CDR.
Jun 02 Initiate design of airborne experiment.
Oct 02 Execute ground-based experiment.
Jan 03 Airborne experiment CDR.
Jul 03 Execute airborne experiment.
Sep 03 Initiate detailed prototype system design.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Sensors and Exploitation Systems SGT-04	76.591	74.206	72.720	73.286	92.582	92.832	92.832	92.832	Continuing	Continuing

(U) **Mission Description:**

(U) The Sensors and Exploitation Systems project funds the development and demonstration of advanced sensors and systems to exploit sensor products. These efforts, in conjunction with those described in Projects SGT-01, SGT-02, and SGT-03, seek to develop the systems needed to provide the warrior with situational awareness and precision target identification and attack capability, with particular emphasis on the most stressing threats. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; provide real-time, accurate Battle Damage Assessment (BDA); and provide semi-automated recognition, robust, precise and reliable identification, and precision fire control tracking and engagement of high value units and critical moving targets. These goals are being addressed by the following programs: Counter CC&D; Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); Moving and Stationary Target Acquisition and Recognition (MSTAR); Surface Target Identification for Engagement (STRIDE); Eyeball, a multispectral electro-optical (EO)/infrared (IR)/radar identification concept; Airborne Video Surveillance (AVS); Affordable Moving Surface Target Engagement (AMSTE); Real-Time Battle Damage Assessment (SAR BDA), Tactical Targeting Network Technologies; and Organic Ground Moving Target Identification (GMTI) Radar (OGR).

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under foliage and camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (detect 80% of the targets with 0.1 FA/sq.km) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR is being developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem is being developed to provide real-time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing, and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended via the Multisensor Exploitation Testbed (MSET) for FOPEN. The program will ultimately combine FOPEN SAR with other airborne sensors (e.g., the Senior Year Electro-Optical Reconnaissance System on the U-2 and ASARS X-band SAR) and modes (GMTI / passive signal detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses are also being conducted to evaluate the capability for FOPEN Ground Moving Target Identification (GMTI) and Electronic Support Measures to increase the effectiveness of future Counter CC&D systems.

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(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from manned reconnaissance aircraft and Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR) - real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery from areas representing multiple terrain types (desert, mountain, littoral) using standard reference imagery products from the National Imagery and Mapping Agency; Activity Monitoring (AM) - reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.); and Multiple Target Surveillance (MTS).

(U) The goal of the Affordable Moving Surface Target Engagement (AMSTE) program is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land- and sea-based), using netted tactical and theater ground moving target indication (GMTI) sensors and weapons. The precise cueing from the netted GMTI sensors will allow for lower-cost weapons by reducing the complexity of precision munitions. Weapons system architectures will be developed and integrated to support a series of precision fire control bomb-drop field experiments and demonstrations. In-flight midcourse and terminal guidance to weapons will also be implemented to demonstrate weapon system CEPs an order of magnitude below current systems against moving targets. A number of critical technologies must be developed including unaided precision grid locking techniques, low-cost weapon data links, low-cost weapon seekers and advanced multi-platform tracking algorithms for both precision and long-duration, high-confidence track purity using phenomenological features. Additionally, battle management, command, control, and communications (BM/C3) experiments will be pursued jointly with Service partners to enable rapid inclusion of precision targeting of movers into future operational architectures.

(U) The Eyeball program, a multispectral EO/IR/Radar identification concept, is founded on the fact that prospective radar assets will be able to detect, locate and provide some forms of target classification. Because of radar and signature limitations, the identification provided may be insufficient for actual targeting and allocation of attack assets. The Eyeball program will investigate novel concepts for standoff identification of moving targets by electro-optical sensors working in conjunction with air- and space-born radar Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) sensors. Once identified, the targets can be tracked using the same radar-based assets. This program will test sensors combining various degrees of spatial resolution, possibly with polarimetric and spectral sensitivity, to identify targets at standoff ranges. The program will also develop concepts for providing this capability on fielded and fieldable platforms.

(U) The goal of the Real-Time Battle Damage Assessment (R/T BDA) program is to develop and evaluate technology to permit all-weather, in-theater assessment of the effects of precision weapons on mobile threat targets such as surface-to-air missile launchers, theater surface-to-surface missile launchers, and multiple rocket launchers. R/T BDA will exploit organic and theater synthetic aperture radar sensors to assess effectiveness

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of munitions delivery and provide feedback to attack systems in mission, with a goal of providing weapon effectiveness metric feedback to the operator within 10 minutes of engagement. R/T BDA will also develop and demonstrate very low-cost, "pop-off" sensors deployed from incoming weapons at pre-determined times before weapon impact. R/T BDA will focus on identifying and assessing weapons effects from precision guided munitions, submunitions, sensor-fuzed weapons, and weapons that typically provide less energetic effect on the target and are, therefore, more difficult to assess by traditional BDA techniques.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technologies required to enable a low-cost capability for the detection and tracking of moving vehicles and personnel through foliage. The goal is to detect vehicles at ranges of 6-10 km and personnel at ranges of 3-5 km with low false alarm rates. The concept is based on the use of separate transmitters and receivers, each of which is designed for low cost and portability. The transmitter can be either an "organic" transmit asset that is attached to an Army or Marine unit, or non-cooperative transmitters of opportunity such as HDTV stations. False alarm reduction and target tracking will be achieved through the creation of multiple narrow azimuth receive beams using high-speed digital beam forming computers. To ensure adequate foliage penetration, the system will be designed to operate in the VHF-UHF frequency regime. The ultra-miniature receivers located at each receive antenna array will be connected to the central signal processor via fiber optic links for ease of setup and to provide for the reduced cost and weight of the overall system.

(U) The goal of the Surface Target Identification for Engagement (STRIDE) program is to achieve confirmed identification of surface targets through a combination of rapid deployment of "eyes-on-target" and novel sensing approaches including multi-look 3-D ladar. STRIDE will develop and demonstrate affordable, rapid means for delivering systems to perform primary or secondary identification of the most stressing surface targets, including those under foliage or camouflage and advanced decoys. Delivery means may include gun launching or deploying from existing deployment mechanisms such as towed decoy tubes. For the most stressing threats, close-in 3-D sensing will be optimally combined with advanced standoff RF techniques to provide reliable, affordable identification under virtually all rules of engagement.

(U) There is an increasing trend across the Armed Services towards the use of tactical computer-to-computer communications networks (ex. JTIDS) for a variety of missions. Emerging networked targeting applications, designed to keep fleeting targets at risk, impose unprecedented network reconfigurability demands. The Tactical Targeting Network Technologies (TTNT) program will develop, evaluate and demonstrate rapidly reconfigurable, affordable, robust, interoperable and evolvable communications technologies specifically to support this critical application class. Specifically, the program will develop and demonstrate a prototype distributed tactical network capable of reconfiguration in fractions of a second.

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(U) The Semi-Automated IMINT Processing (SAIP) ACTD, which ended in FY 2000, has developed, tested and transitioned to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO, imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes).

(U) The Moving and Stationary Target Acquisition and Recognition (MSTAR) program achieved a major advance in Automatic Target Recognition (ATR) performance based on the use of SAR imagery. This was accomplished through fundamental and innovative technology and algorithmic developments, large-scale data collections, and detailed system evaluations. The approach detected stationary targets utilizing traditional ATR techniques to first determine suitable target candidates for those image regions of interest (ROIs) that were selected based on their likelihood of target content. A model-driven subsystem then refined these target candidates by using a SAR signature prediction module to determine the true target ID of the target within the ROI. FY 2000 is the final year of funding for MSTAR.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- SAIP ACTD. ($ 4.401 Million)
  - Operational support to the Army and Air Force SAIP residual operational capability was completed.
- MSTAR. ($ 15.466 Million)
  - Using newly collected SAR data, the MSTAR program demonstrated major improvements in ATR performance as a function of resolution. Recognition capabilities using RF returns without forming the imagery were investigated. An integration and transition capability was established in the Real Time ATR Laboratory (R/T ATR Lab) for the purpose of developing MSTAR based "modules" that can be used to upgrade operational ATR systems such as SAIP. The ability to operate the MSTAR system in near real time was demonstrated through the use of parallel super-computers in the R/T ATR Lab. Concurrently, a toolkit of interactive exploitation tools, integrated with commercial technology, provided operationally useful ATR capabilities to image analysts. Finally, an initial exploration was conducted of MSTAR model-based reasoning technology using SAR data in conjunction with 3-D Laser Radar (LADAR) data of ground targets.

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- AVS. ($ 10.876 Million)
  - Integrated, demonstrated and evaluated the following technologies in the laboratory and in some limited field experiments: Activity Monitoring – monitored activities (e.g., soldier incursion into security zones, tactical and strategic vehicle movement) and developed activity-based indexes for tactical video data stores. Moving Target Surveillance – demonstrated increased reliability of multiple target tracking and reacquisition and developed technology for the geolocation of moving targets in multiple terrain types and imaging conditions. Precision Video Registration – Demonstrated 2 to 10 meter absolute geolocation accuracy in 80 percent of mission imagery from multiple terrain types.

- Counter CC&D. ($ 26.613 Million)
  - The Counter CC&D Program completed hardware development and system integration, and began conducting preliminary flight tests of the FOPEN SAR Manned Airborne Demonstrator on an Army RC-12 aircraft. This demonstration (when completed) will verify that the system meets image quality with real time tactical data link operational constraints. The Multi-Sensor Exploitation Testbed (MSET) will focus on the development of SAR and spectral MSI image feature fusion techniques to demonstrate the achievable performance gain in overall detection and false alarm rate with multimode systems. These capabilities will be utilized with the ATD/C algorithms to demonstrate and project Counter CC&D capabilities in a CIGSS compliant architecture. Concept development studies and one preliminary data collection experiment was completed for FOPEN GMTI/ESM. A moving target RCS measurement experiment was conducted and a second data collection experiment with an airborne UHF GMTI sensor was begun.

- AMSTE. ($ 14.382 Million)
  - A weapon system trade study of "higher-order" error terms and initial precision fire control tracking experiments was completed. The study products included an end-to-end operational system design, end-to-end concept of operations, and system performance analysis. Multisensor registration, association and tracking algorithms were developed, and iterative experimentation was conducted using simulated and real multi-sensor GMTI data confirmed the theoretical predictions of less then 10 m targeting errors. Data from multi-sensor data collections were used directly in tracker experiments, and analysis of these data validated sensor accuracy models used in simulations, supporting the results of earlier tracking experiments.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

- Organic GMTI Radar (OGR). ($ 4.853 Million)
  - Organic GMTI Radar (OGR) program completed the fabrication and initiated the evaluation of the brassboard proof-of-concept system. Planning for an experiment using an HDTV transmitter has begun. Planning for full scale testing and evaluation has begun. A separate study has investigated the performance limitations when using non-rigid antenna structures for the receiver array.

(U) **FY 2001 Plans:**

- AVS. ($ 8.955 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate Precision Video Registration technology in laboratory systems and in field experiments. AVS will demonstrate 2 to 10 meter absolute geolocation accuracy in 90 percent of mission imagery from multiple varieties of terrain types. AVS will characterize geolocation performance with respect to varying real world imaging and terrain conditions, and provide this technology for transition.

- Counter CC&D. ($ 15.766 Million)
  - The Counter CC&D Program will conduct developmental flight tests to gather data on targets and backgrounds for algorithm training, and will perform validation flights to demonstrate that the system meets the target detection and false alarm goals. The program will begin a yearlong phase of user demonstrations of the FOPEN SAR on the ARMY RC-12 that will be conducted with Army and Air Force exercises. Efforts will begin on rehosting MSET to SAIP residual for field demonstrations. FOPEN GMTI/ESM data analysis will be completed.

- AMSTE. ($ 29.000 Million)
  - Design, development and fabrication of the initial field experiment system will be completed, including airborne sensors modified to support fire control, data links, processing with a real-time fire control tracker, and a weapon data link. Field experiments will be conducted to evaluate the capability to perform precision fire control targeting against moving targets, culminating in an inert weapon drop. Field experiments will be augmented with additional laboratory weapon system evaluations using data recorded during field experiments. Laboratory analyses will include investigation of various levels of sensor performance, use of a low-cost terminal guidance seeker, and extrapolation to operational systems. Advanced target track maintenance techniques will be developed for integration into the precision fire control tracker and tested in the laboratory on recorded data to support subsequent AMSTE field experiments.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

- Organic GMTI Radar (OGR). ($ 4.000 Million)
  - The Organic GMTI Radar (OGR) program will start the fabrication of an operational demo system.
  - The design and fabrication of a low-cost full-scale receive array will be initiated.
  - Additional experiments will be conducted at multiple sites using bistatic modes with dedicated transmitters and transmitters of opportunity.

- Eyeball. ($ 1.985 Million)
  - Establish sensor limits and primary trades; investigate novel concepts for cross-cued systems.
  - Complete modeling efforts and phenomenology trades.
  - Complete preliminary design of demonstration/experimental system.
  - Explore feasibility to exploit microdoppler target signature for identification purposes.

- Real-Time Battle Damage Assessment (R/T BDA). ($ 6.500 Million)
  - Evaluate and/or develop RF algorithmic techniques and inexpensive weapon-mounted imagers to provide near real-time, all-weather assessment of precision weapons effects on high-value mobile threat targets.
  - Investigate RF techniques to exploit change detection to identify weapons-effects signatures in synchronized pre- and post-strike SAR imagery, and couple this signature assessment with real-time prediction of target functional degradation.
  - Precision munition "pop-off" BDA sensor preliminary designs will be conducted for a range of weapons.
  - Initiate data collection efforts.

- Surface Target Identification for Engagement (STRIDE). ($ 8.000 Million)
  - Analyze a variety of secondary identification deployment means including gun launching and deployment from towed decoy tubes.
  - Select candidates and begin preliminary designs.
  - Initiate novel Laser Radar (LADAR) and RF exploitation technologies for ID of decoys and targets under foliage or camouflage.
  - Initiate compact 3-D LADAR risk reduction activities.

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(U) **FY 2002 Plans:**

- Counter CC&D. ($ 7.884 Million)
  - Design, coordination, and field demonstration of Counter CCC&D concept in CONUS and OCONUS environments.

- AMSTE. ($ 35.420 Million)
  - Design, development and fabrication of an enhanced field experiment system will be completed, to support evaluation of moving target engagement capabilities. Field experiments will be conducted to evaluate the capability to provide complete kill-chain integration from standoff detection, through continuous track maintenance, to the precision fire control end game targeting of moving vehicles. Field and laboratory experimentation will be focused on more complex target densities and target dynamics. A full AMSTE weapons delivery capability will be demonstrated in live weapons drops. Advanced target track maintenance techniques will be integrated into the system to support field experiments.

- Organic GMTI Radar (OGR). ($ 1.682 Million)
  - The OGR program will complete the fabrication of an operational demo system and conduct operational utility field tests.

- Eyeball. ($ 5.936 Million)
  - Complete final design of demonstration/experimental system.
  - Initiate experiments at government-determined site.
  - Finalize microdoppler target signature feasibility.

- TTNT. ($ 2.700 Million)
  - Conduct tactical networking reconfigurability design study.
  - Initiate network management and resource allocation algorithm and simulation development.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

- Real-Time Battle Damage Assessment (R/T BDA). ($ 9.000 Million)
  – Develop robust candidate RF algorithmic techniques and evaluate against data collected from instrumented live fire testing.
  – Develop planning and sensor management tools to support R/T BDA BM/C3
  – Complete weapon-mounted imager development and conduct captive carry assessment.
  – Develop 3-D, geometry-based, coupled target signature/weapons effectiveness assessment models.

- Surface Target Identification for Engagement (STRIDE). ($ 10.098 Million)
  – Fabricate and test gun launched close-in-sensor delivery vehicle.
  – Perform sensor and delivery vehicle integration for gun-launched system.
  – Select alternative delivery system options and sensor combinations.
  – Conduct LADAR experiments on stressing targets.
  – Preliminary design of advanced target discrimination algorithms.

(U) **FY 2003 Plans:**

- AMSTE. ($ 30.006 Million)
  – Design, development and fabrication of the final field experiment system will be completed, to support demonstration and evaluation of moving target engagement capabilities in an integrated operational environment. Field experiments will be conducted, utilizing realistic threats, environments and threat doctrine to demonstrate and evaluate the capability to provide a complete, integrated end-to-end technical capability for targeting and engaging moving vehicles. Demonstration focus will include integration of operational sensors and live weapons with operational battle management/command and control.

- Eyeball. ($ 6.000 Million)
  – Complete demonstration/experimental system.
  – Validate phenomenology/experiments at government-determined site.
  – Validate microdoppler target signature.

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- TTNT. ($ 11.000 Million)
  - Continue simulation and initiate hardware-in-the-loop proof-of-principle demonstrations.
  - Initiate design and conduct PDR of prototype tactical network.

- Real-Time Battle Damage Assessment (R/T BDA). ($ 11.280 Million)
  - Perform integrated R/T SAR BDA experiments/demonstrations utilizing real time tasking, sensor exploitation, and effects assessment in live fire environment.
  - Demonstrate "Pop-Off" BDA sensor in proof-of-principle live fire experiment.

- Surface Target Identification for Engagement (STRIDE). ($ 15.000 Million)
  - Perform component and g-level testing of gun launched delivery vehicle with integrated sensor package.
  - Conduct system flight tests of gun launched close-in-sensor package.
  - Perform alternate delivery system test and evaluation.
  - Develop real time computational methodologies for target visualization, discrimination, and ID.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
May 00	MSET MSI/HIS/X-Band SAR Counter CC&D data collection
Jun 00	AMSTE weapon system trade studies concluded.
Jun 00	Lab demonstration of Airborne Video Surveillance video geolocation technology.
Jun 00	FOPEN radar moving targets signature experiment.
Jul 00	Preliminary flight demonstration of FOPEN radar on manned platform.

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Jul 00	Preliminary MSET data collection results.
Sep 00	Bistatic OGR experiments using HDTV transmitter.
Sep 00	FOPEN GMTI radar data collection.
Sep 00	AMSTE real-time precision fire control laboratory experiment completed.
Sep 00	Design of AMSTE precision engagement demonstration system completed.
Sep 00	MSET integrated demonstration.
Sep 00	MSTAR demonstration of 25 different target types using full operational conditions and significant reduction in false alarm rates.
Sep 00	Completion of MSTAR Advanced Concepts evaluation.
Oct 00	AVS video geolocation and activity monitoring labs and field experiments.
Oct 00	MSET fusion algorithm.
Oct 00	OGR final operational RF selection and start operational demo system fabrication.
Nov 00	FOPEN GMTI/ESM concept development studies completed.
Nov 00	Verification of MSET fusion algorithm enhancements.
Jan 01	Modeling and phenomenology and data report. (Eyeball)
Jan 01	R/T BDA SAR imagery data collection.
Feb 01	Completion of Eyeball data collection plan, preliminary data analysis results. (Eyeball)
May 01	R/T BDA weapon deployed imager design completed.
May 01	STRIDE secondary identification preliminary designs begin.
Jul 01	OGR award for fabrication of low cost, lightweight operational receive antenna.
Aug 01	Verification of FOPEN SAR automatic target detection and cueing.
Aug 01	Completion of modeling and phenomenology.
Aug 01	STRIDE advanced RF technique evaluation completed.
Sep 01	MSET re-host to SAIP residual for field demonstrations.
Sep 01	User evaluation of FOPEN SAR operational utility.
Sep 01	AMSTE initial airborne precision fire control and engagement field demonstration.
Oct 01	AVS lab and field experiments for user evaluations and technology transition.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

Oct 01	Completion of Eyeball preliminary/experimental designs. Completion of sensor limits report.
Nov 01	STRIDE target ID demonstration.
Feb 02	Initiation of experimentation at government determined site.
Jun 02	STRIDE complete gun launched delivery system tests.
Jun 02	OGR operational utility demo.
Sep 02	AMSTE live weapons demonstration and track maintenance integration field experiment.
Sep 02	TTNT preliminary design of network management and resource allocation algorithms.
Nov 02	STRIDE demo use of advanced target ID algorithms.
Jun 03	STRIDE demo preliminary real-time processing concepts.
Aug 03	STRIDE complete flight tests of gun delivered system, start demo flight planning.
Aug 03	AMSTE end-to-end system operational demonstration with BM/C3 integration and full threat dynamics.
Aug 03	Completion of experimentation/ground based demonstration.
Sep 03	TTNT network design PDR.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development						R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E				
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	21.107	30.304	30.257	42.896	47.696	57.496	80.196	92.596	Continuing	Continuing
Advanced Ship-Sensor Systems, MRN-02	21.107	30.304	30.257	42.896	47.696	57.496	80.196	92.596	Continuing	Continuing

(U) **Mission Description:**

(U) The objective of the Marine Technology Program is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) maintenance of US naval force access to the littoral by countering the threat created by the worldwide spread of increasingly sophisticated technology; 2) enhancement of the ability of US naval forces to interrogate and dominate the maritime battlespace, particularly in the littoral arena; 3) advances in the ability of US naval assets to conduct operations as a seamlessly networked and integrated theater level force; and 4) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle. Proliferating threats such as modern cruise missile technology, commercially available overhead surveillance, advanced undersea mine capabilities, and modern, quiet diesel/electric submarines, pose major challenges for operations in the restricted water, near-shore regimes that are of growing importance to US strategic considerations, necessitating continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral. This program element consists of a single project, Advanced Ship-Sensor Systems (MRN-02), comprised of the following programs: Undersea Littoral Warfare (ULW), Water Hammer, Buoyant Cable Array Antenna (BCAA), Robust Passive Sonar (RPS), Future Submarine Payloads program, Rapid Deployment and Logistics Ship program, and Advanced Maritime Propulsion program.

(U) The Undersea Littoral Warfare (ULW) program is completing the Netted Search, Acquisition, and Targeting (NetSAT) system, a networked approach for improved attack performance that exploits the use of a sonobouy field during the weapon run to identify, locate, and mitigate the impact of countermeasures and target evasion tactics on torpedo operation. A bi-directional fiber optic link enables return of torpedo information to a processor servicing the other sensors on the network in addition to providing a command link for the weapon. The ability to rapidly discern the geographic picture from multiple viewpoints is expected to provide major (10x) torpedo performance improvements in strong countermeasure environments while requiring only modest modification of existing torpedo inventories. In addition, the ULW program is developing approaches to Synthetic Aperture Sonar (SAS) that would revolutionize our ability to classify and identify underwater mines and

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improve search rates more than an order of magnitude greater than is possible with current techniques. A comprehensive proof of performance demonstration will be conducted to assure readiness for transition to formal development programs.

(U) The Buoyant Cable Array Antenna (BCAA) program is developing an antenna capable of supporting full duplex (transmit and receive) connectivity for voice and data with communications satellites while floating on the ocean's surface. Towed behind a submarine, this capability will enable high quality, high data-rate connectivity with other military assets, even while operating at speed and depth. Supporting technologies to be developed include photonic signal and power links, enhanced antenna loading materials, processing algorithms for blind adaptive array calibration and washover mitigation, advanced communications protocols, and signature minimization techniques. In addition, the feasibility of related approaches to radio frequency (RF) communications at higher frequencies in a package physically remote from the actual submarine platform will be assessed.

(U) The Robust Passive Sonar (RPS) program is an outgrowth of the successful experiments performed under the ULW program. The RPS program will investigate the ability of innovative, optimal processing approaches, coupled as appropriate to multi-dimensional receive arrays and/or external information, to precisely cancel the acoustic interference generated by surface shipping. At the lower frequencies that increasingly dominate submarine detection by acoustic means, shipping interference represents the primary noise background limiting the performance of existing sonar systems; this is especially true in the dense shipping environment typical of many littoral areas. Precise notching of shipping interference could result in net system performance gains of 10-20 dB, and the means of accomplishing it are expected to dictate preferred future array and acoustic sensor field designs. A data-driven program of algorithmic development and performance demonstration will be conducted as a multi-disciplinary effort. Participation across a broad spectrum of organizations in close coordination with Navy resources and organizations is intended.

(U) The Future Submarine Payloads program will continue to build upon the concepts generated under the Sub Payloads and Sensors program (PE 0602702E, Project TT-03). Mature and promising concepts will be further developed to expand the effectiveness and lethality of US submarine platforms.

(U) The Rapid Deployment and Logistics Ship program will investigate and bring to fruition innovative concepts in ship-based transport of ground forces into theater. New technology advances will be combined with current state-of-the-art technologies from the oil drilling industry and surface container shipping industry. The ultimate goal is to provide US commanders with massive amounts of offshore basing, firepower and logistics capabilities in theater on short notice.

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(U) The Water Hammer program conducted concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi).

(U) The Advanced Maritime Propulsion program will investigate advanced propulsion systems for both surface and sub-surface naval vessels.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Undersea Littoral Warfare (ULW). ($ 15.874 Million)
  - Completed development of prototype NetSAT system.
  - Conducted NetSAT follow-on technical demonstration, improved endgame coordination with existing systems for final target updates to improve overall effectiveness.
  - Conducted mine target strength and target structure studies in support of advanced classification techniques for Synthetic Aperture Sonar (SAS) systems; compared predictive models with laboratory measurements.
  - Assessed Robust Passive Sonar (RPS) performance improvements in passive sonar from exploitation of external information (overhead surveillance and acoustic monitors).
  - Commenced RPS development of space-time processing algorithms for advanced surface shipping interference rejection.

- Buoyant Cable Array Antenna (BCAA). ($ 4.483 Million)
  - Conducted component technology risk reduction and maturation.
  - Initiated design and development of a full duplex (transmit/receive) submarine BCAA prototype antenna.
  - Completed system definition for prototype; conducted preliminary design review.

- Water Hammer. ($ 0.750 Million)
  - Completed and tested 4x4 source array.
  - Validated nonlinear numerical model from test results.

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(U) **FY 2001 Plans:**

- Undersea Littoral Warfare (ULW). ($ 20.693 Million)
  - Conduct final NetSAT operational demonstration.
  - Commence integration of Synthetic Aperture Sonar (SAS) testbed for proof of performance testing; integrate end-to-end SAS processing chain in laboratory.
  - Continue development of space-time processing algorithms for advanced surface shipping interference rejection.
  - Commence development of noise-rejection algorithms exploiting external information.
  - Conduct initial RPS field exercises for site survey and acoustic data collection.
  - Commence design and development of testbed array as continuing source of shallow water acoustic field data.
  - Create baseline integrated RPS interference rejection processing stream.
  - Conduct preliminary performance assessment.

- Buoyant Cable Array Antenna (BCAA). ($ 9.611 Million)
  - Complete algorithm and software development for space-time adaptive communications link processor.
  - Complete design of BCAA prototype antenna; conduct critical design review.
  - Fabricate BCAA prototype antenna; commence integration with submarine deployment and retrieval systems.

(U) **FY 2002 Plans:**

- Future Submarine Payloads Program. ($ 4.896 Million)
  - Conduct structural, material and architectural trade studies for new intelligence, surveillance and reconnaissance sensor systems for submarines.
  - Investigate feasibility of improved underwater communication systems for submarines.

- Buoyant Cable Array Antenna (BCAA). ($ 2.930 Million)
  - Complete integration of BCAA prototype antenna with submarine deployment and retrieval systems.

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- Complete at-sea technical validation of BCAA prototype from surface platform.
- Conduct at-sea operational demonstration of BCAA prototype from submarine.
- Transition BCAA technology to Navy for follow-on development.

• Robust Passive Sonar (RPS). ($ 9.931 Million)
- Continue development of space-time processing algorithms for advanced surface shipping interference rejection and for exploiting external information.
- Commence development of processing algorithms for extended temporal integration and tracking of interferors and targets.
- Conduct installation of initial testbed array modules; commence data collection from the testbed array.
- Conduct follow-on performance assessment based on testbed data.
- Commence performance trade studies of alternative acoustic array concepts.

• Rapid Deployment and Logistics Ship. ($ 11.000 Million)
- Develop initial engineering design.
- Develop water tank models.
- Test wave drafting concepts.

• Advanced Maritime Propulsion. ($ 1.500 Million)
- Continue investigation into advanced propulsion systems for surface and sub-surface naval vessels.

(U) **FY 2003 Plans:**

• Robust Passive Sonar (RPS). ($ 13.896 Million)
- Complete development of space-time processing algorithms for advanced surface shipping interference rejection and for exploiting external information.
- Continue development of processing algorithms for extended temporal integration and tracking of interferors and targets.
- Conduct performance comparisons between testbed and mobile acoustic systems.

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- Conduct installation of follow-on testbed array modules; continue testbed array data collection and associated performance assessments.
- Continue performance trade studies of alternative acoustic array concepts with testbed data.

• Future Submarine Payloads Program. ($ 6.000 Million)
- Conduct structural, material and architectural trade studies among various new weapons systems that will increase target sets accuracy, power projection and lethality over current submarine weapon systems.

• Rapid Deployment and Logistics Ship. ($ 17.000 Million)
- Perform water tank tests.
- Commence scale model development.
- Characterize deck stability of various models.

• Advanced Maritime Propulsion. ($ 6.000 Million)
- Continue investigation into advanced propulsion systems for surface and sub-surface naval vessels.

(U) **Program Change Summary:** *(In Millions)*

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	21.681	30.304	38.257	54.896
Current Budget	21.107	30.304	30.257	42.896

(U) **Change Summary Explanation:**

FY 2000	Decrease reflects minor repricing and SBIR reprogramming.
FY 2002 - 03	Decrease reflects a shift of the Drug Reduction program from this project (MRN-02) to PE0602702E (TT-03), in recognition that the effort required further 6.2 development activity before transitioning to the Advanced Technology Development Budget Activity.

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(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Undersea Littoral Warfare (ULW):	
Jul 00	Conduct follow-on technical demonstration of prototype NetSAT system in a controlled test range environment
Sep 00	Conduct mine target strength studies in support of advanced classification techniques for SAS.
May 01	Initial end-to-end SAS processing chain complete.
Jun 01	Conduct sensor-to-shooter operational demonstration including surveillance detection, handoff, targeting and attack in a countermeasure environment.
Dec 01	SAS classification performance assessment complete.
Apr 02	Conduct SAS data collection exercises.
Water Hammer:	
Sep 00	Complete 4 x 4 Water Hammer source array and test subsystem.
Buoyant Cable Array Antenna (BCAA):	
Jun 00	Conduct Preliminary Design Review (PDR) for BCAA prototype system.
Apr 01	Conduct Critical Design Review (CDR) for BCAA prototype system.
Mar 01	Conduct feasibility assessment for remotely operated submarine communications concepts.
Nov 01	BCAA multi-element antenna prototype system complete.
Apr 02	Conduct surface ship system test.
Sep 02	Conduct submarine system demonstration.

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Robust Passive Sonar (RPS):

Mar 01	Initial RPS data collection field exercise complete.
Jun 01	Baseline interference rejection processing stream for passive sonar created.
Sep 01	Preliminary RPS performance assessment complete.
Sep 01	Install initial testbed array modules.
Oct 01	Commence data collection from testbed array.
Jun 02	Update performance assessment based on data collected.
Dec 02	Conduct performance comparison between testbed and mobile acoustic systems.
Mar 03	Install follow-on testbed modules. Continue data collection for performance assessment and study of alternative acoustic arrays concepts.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	93.608	134.249	147.667	176.100	123.000	82.000	92.000	92.000	Continuing	Continuing
Rapid Strike Force Technology LNW-01	51.522	38.129	19.992	16.500	27.500	32.000	32.000	32.000	Continuing	Continuing
Small Unit Operations LNW-02	42.086	35.120	37.675	37.600	33.500	35.000	45.000	45.000	Continuing	Continuing
Future Combat Systems LNW-03	0.000	61.000	90.000	122.000	62.000	15.000	15.000	15.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Three broad efforts are being pursued in support of this objective: Rapid Strike Force Technology, Small Unit Operations and Future Combat Systems.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project include: 1) the Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program that will design, develop, test and transition a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles to the Services; 2) the Solar Blind Detectors program that will develop technologies to enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles; 3) the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; 4) the Mobile Tactical Operation Center/Future Ground Combat System program that will explore and develop technologies to be used by tactical commanders in situational awareness, communications and control; and 5) the Metal Storm program that will develop a system to pack, transport and fire at variable sequence rates.

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(U) The goal of the Small Unit Operations project is to develop critical technologies that will enable dispersed units to effectively perform warfighting operations traditionally requiring massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

(U) The Future Combat Systems project goal is to develop the optimal balance among critical performance factors, including ground platform strategic, operational and tactical mobility, lethality, survivability and sustainability. Efforts will focus on creating a multi-functional, multi-mission, re-configurable group of systems that maximize joint interoperability, strategic transportability and commonality of mission roles. These efforts will concentrate in six areas: robotics; unmanned ground vehicles; maneuver command, control and communication; beyond line of sight fires; organic all weather air vehicles; and organic all weather targeting. Support programs will develop rapid response and lethality packages requiring fewer personnel, decreased logistical support and lower life-cycle costs while increasing survivability.

(U) **Program Change Summary:** (*In Millions*)

	FY2000	FY 2001	FY 2002	FY 2003
Previous President's Budget	96.320	134.249	157.667	161.100
Current Budget	93.608	134.249	147.667	176.100

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects SBIR reprogramming and minor program repricings.
FY 2002 Decrease reflects the phase down of Advanced Sensing Technologies and other Agency reprioritization.
FY 2003 Increase reflects planned expansion of the Wolfpack and Advanced Camouflage Techniques programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	51.522	38.129	19.992	16.500	27.500	32.000	32.000	32.000	Continuing	Continuing

(U) **Mission Description:**

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient, land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Reconnaissance, Surveillance and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Solar Blind Detectors; Metal Storm (MS); Combat Hybrid Power Systems (CHPS); Future Ground Combat System (FCS); and the Advanced Camouflage Techniques program. These programs are closely coordinated with the US Army, Navy and Marine Corps, and with DARPA's Small Unit Operations (LNW-02) project.

(U) The Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate and transition to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension, including both active and passive approaches. The vehicle will also host integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting (RST) sensor subsystems. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ATD as well as address joint US Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV) and Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

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(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with a team of semi-intelligent, cooperating robot prototype platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: machine perception, autonomous operation and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction and (b) traversal of rugged/complex terrain using one command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to one meter per second over 25 cm steps and decimeter-scale rubble with open terrain sprint speeds of three meters per second.

(U) The Solar Blind Detectors program (formerly titled "Vehicle Self-Protection") will develop an ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

(U) The Combat Hybrid Power System program will developed enabling technologies and conducted demonstrations of an integrated hybrid electric power system to provide power and energy management for all of the electric subsystems throughout future combat vehicles. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. These advantages will result in deployable, affordable combat vehicles that meet mission requirements. The program is transitioning to the Army in 2001, and the technologies developed are expected to play a key role in the future combat system.

(U) The Future Combat Systems (FCS) program, an out-growth of the Mobile Tactical Operations Center, will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of integrated command and control capabilities with unsurpassed situational understanding for all levels of commanders. This system will be transitioned to the U.S. Army for full development and ultimate deployment in the 2012 timeframe. The Future Combat Systems (FCS) will be a multi-functional, multi-mission re-configurable system of systems to maximize joint inter-operability, strategic transportability and commonality of mission roles including direct and indirect fire, air defense, reconnaissance, troop transport, counter mobility,

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non-lethal and C2 on the move. The goal of this effort is to develop a network centric advanced force structure, quantify its benefits and identify materiel solutions and technologies within the context of that force. It will also identify Doctrine, Operational, Training, Leader and Material (DOTLM) specific changes necessary as a result of the development of this network centric advanced force structure. In FY 2001, the FCS program will be funded from project LNW-03, Future Combat Systems, within Program Element 0603764E.

(U) The Metal Storm (MS) program will develop a unique 100 percent solid state system for tightly packing, storing, transporting and firing projectiles in multiple tubes with high or low pressures, in an infinitely variable sequence rate with applications to small arms and crew served weapons. The program facilitates current US force reduction and restructuring policies while increasing firepower. The program will demonstrate revolutionary in weapon designs and applications that will far exceed the effectiveness and versatility of existing small arms and large munitions weaponry. This program will primarily focus on developing, fabricating and testing two 7.62 mm sniper rifle prototypes for Special Operations Forces use. The design will incorporate a multi-barrel configuration allowing instant access to a variety of projectiles. Studies will be conducted to optimize propellants and projectiles; to examine electronic keying, silencing and underwater operations; and to investigate the physics of scaling from a small caliber, low pressure design to a large caliber (40 and 81mm), modest barrel pressure (~60,000 psi) design. Through a Project Arrangement under the Deutsch Ayers Agreement between the US and Australia, the Defence Science & Technology Office (DSTO) will perform work in the areas of scaling, modeling and simulation, and small arms live fire testing.

(U) The Advanced Camouflage Techniques (ACT) program will develop technologies that will significantly improve the ability of early entry and special operations forces to camouflage valuable assets. The ACT program will investigate multi-purpose approaches using recent advancements in perception, processing and pigment/variable dye techniques and integrate them into useable systems for U.S. Forces.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Combat Hybrid Power Systems (CHPS). ($ 10.074 Million) [Future Combat Systems – related = $10.074 million]
  - Installed engine and thermal management system in the Systems Integration Laboratory (SIL) and operated the system with various combinations of engine, flywheel and battery to determine performance baselines for notional concept vehicle (15 tons).
  - Completed advanced, high-risk hybrid electric power system components, including the high energy/high power CHPS Lithium Ion Battery and Silicon Carbide DC/DC converter.

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- Investigated alternative power system component technologies, including Ultra capacitors and in-wheel hub motors.
- Initiated testing and evaluation of integrated hybrid electric power system and subsystems.
- Developed a plan to systemically investigate and qualify benefits of hybrid electric power for future combat vehicles using SIL and hardware-in-the-loop virtual prototype.
- Developed coordinated research plan for continued effective utilization of CHPS SIL and virtual prototypes.
- Developed plan to ensure smooth transition of CHPS program to U.S. Army Tank-Automotive and Armaments Command (TACOM).

• Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 10.651 Million)
- Performed wheel motor qualification tests.
- Performed suspension maturation tests.
- Conducted Automotive Fabrication Readiness Review.
- Demonstrated hardware/software hot bench.
- Completed C^4I Critical Item demonstration.
- Rolled out vehicles 1 and 2.
- Initiated contractor testing of vehicles 1 and 2.

• Tactical Mobile Robotics (TMR). ($ 15.238 Million)
- Initiated development of fully functional tactical robotic prototypes.
- Integrated enabling technologies into functional platforms.
- Refined demonstration and transition plans commensurate with success in system design and multi-platform collaboration.
- Conducted technical experiments in machine perception and autonomous navigation of indoor cluttered environments.

• Solar Blind Detectors Program. ($ 5.679 Million)
- Demonstrated low defect epitaxial material compatible for photo detectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).

• Future Combat Systems (FCS). ($ 6.896 Million)
- Initiated FCS concept design development.

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- Prepared Integrated Development Environment (IDE) for data/programmatic interaction.
- Concept development teams performed initial technology surveys (DoD-wide activities) and initial force capabilities decomposition.
- Developed analysis tools and resources to assess and identify Unmanned Ground Vehicle (UGV) options – Summer Study of UGV design limitations to scope practical objectives for FY2001-2003 efforts.
- Performed initial analysis of physical UGV configuration and component possibilities.
- Identified key paths for prototype/demonstration efforts.
- Demonstrated navigational benefits of higher resolution terrain/environmental data (associated with low latency coordination between UGV and aerial surveillance assets).

• Advanced Concepts Evaluation. ($ 2.984 Million)
- Conducted technology assessment and feasibility testing of advanced rapid strike force concepts including precision guided munitions, force-on-force modeling, counter situational awareness, covert autonomous sensors and future unmanned vehicle systems.
- Conducted studies to optimize the Metal Storm concept, research propellants and projectiles, and developed approaches to enhance accuracy. Established international agreement between the United States and Australia.

(U) **FY 2001 Plans:**

• Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 8.796 Million)
- Deliver vehicles 1 and 2 for participation in U.S. Marine Corps (USMC) Advanced Warfighting Experiment.
- Integrate and demonstrate Survivability Suite.
- Deliver vehicles 3 and 4.
- Evaluate active suspension enhancement of RST-V.

• Tactical Mobile Robotics (TMR). ($ 12.217 Million)
- Complete initial prototype development.
- Complete initial design of Human Robot Interface for multi-robot control, heterogeneous platform collaboration and marsupial operations.

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- Initiate tactical experiment plan with fully functional platforms to determine operational value baseline.
- Refine collective experimentation plan.

• Solar Blind Detectors Program. ($ 5.338 Million)
  - Demonstrate solar-blind detector array with 128 x 128 pixels.

• Metal Storm (MS). ($ 10.778 Million)
  - Finalize designs for main sniper rifle and targeting and electronic subsystems.
  - Perform scaling analysis of Metal Storm technology to larger calibers.
  - Demonstrate preliminary design firing.

• Advanced Concept Evaluation. ($ 1.000 Million)
  - Continue technology assessment and feasibility testing of advanced rapid strike force concepts including all electric and ceramic engine systems, thin film batteries and future unmanned vehicle systems.

(U) **FY 2002 Plans:**

• Reconnaissance, Surveillance and Targeting Vehicle (RST-V). ($ 2.968 Million)
  - Demonstrate V-22 compatibility.
  - Complete RST/ C^4I test.
  - Deliver Phase II final report.

• Metal Storm. ($ 5.919 Million)
  - Demonstrate a single-barrel model of the electronic sniper rifle.
  - Initiate design and tradeoff analysis of a multi-barrel model.
  - Conduct Critical Design Review of the multi-barrel model.

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- Tactical Mobile Robotics (TMR). ($ 3.418 Million)
  - Complete final prototype modifications.
  - Initiate full team integration including multi-modal Human Robot Interface and collaborative platform system.
  - Conduct initial collective platform experiments in unscripted tactical vignettes.
  - Initiate transition to military departments.

- Advanced Camouflage Techniques. ($ 7.687 Million)
  - Investigate recent commercial advancements in perception, processing and pigments/variable dyes and merge them with existing military techniques.
  - Conduct further phenomenology studies.

(U) **<u>FY 2003 Plans:</u>**

- Tactical Mobile Robotics (TMR). ($ 2.000 Million)
  - Complete development of fully integrated Human Robot Team consisting of multiple robots collaborating in a marsupial fashion supporting operational personnel via an efficient, non-distracting interface.
  - Conduct final collective experiments in unscripted tactical missions.
  - Finalize transition to military departments.

- Advanced Camouflage Techniques. ($ 14.500 Million)
  - Focus studies on most promising camouflage techniques and technically demanding components.
  - Begin initial design and review of useable system.

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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY2000	FY2001	FY2002	FY2003
PE 0603640M Marine Corps Advanced Technology Demonstration	2.150	2.750	2.990	0.000
PE 0602601A Combat Vehicle and Automotive Technology	6.586	0.000	0.000	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Technology (FCS)	5.312	0.000	0.000	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Tech (CHPS)	4.700	4.700	4.700	0.000

(U) **Schedule Profile:**

Plan	Milestones
Jul 00	CHPS: Integrate advanced components and demonstrate fully integrated combat hybrid power system laboratory.
Jul 00	TMR: Conduct final technology demonstration and critical design review for selected TMR platforms.
Jul 00	MS: Conduct tradeoff analysis and concept design.
Sep 00	FCS: Technology investment review.
Sep 00	CHPS: Transition contracts to Army TACOM-TARDEC.
Sep 00	MS: Single-barrel preliminary design.
Oct 00	RST-V: Deliver vehicles 1 and 2.
Jan 01	ACT: Complete source selection process.
Mar 01	Demonstrate RST-V system capabilities in Advanced Warfighting Experiment (AWE).
Mar 01	Solar Blind Detectors: Demonstrate Avalanche Photo Detector (APD) array with 100 amps/watt responsity and low dark current.
Apr 01	MS: Complete physics of scaling study.
Jun 01	RST-V: Integrated Survivability demonstration of Reconnaissance, Surveillance and Targeting Vehicle (RST-V).
Jul 01	RST-V: Vehicle 3 delivery.

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Jul 01	TMR: Complete operational demonstrations of Tactical Mobile Robotic systems. Initiate transition and technology transfer plans.
Sep 01	RST-V: Vehicle 4 delivery.
Sep 01	MS: Demonstrate preliminary design firing.
Nov 01	RST-V: Demonstrate V-22 compatibility.
Dec 01	RST-V: RST-V/ C^4I testing complete.
Mar 02	MS: Demonstrate single-barrel electronic sniper rifle.
May 02	RST-V: Phase II final report.
Jun 02	ACT: Complete initial architecture of system.
Aug 02	MS: Multi-barrel electronic sniper rifle Critical Design Review.
Sep 02	TMR: Complete transition and technology to military services.
Nov 02	ACT: Commence pattern-matching effort.
Jul 03	ACT: Finalize initial design review.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Small Unit Operations LNW-02	42.086	35.120	37.675	37.600	33.500	35.000	45.000	45.000	Continuing	Continuing

(U) **Mission Description:**

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threats are located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technologies are poorly configured to operate in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and are not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Small Unit Operations Project is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that "glue" the components together, operate in any environment, are covert and resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden. The programs that make up this project include the Situational Awareness System (SAS), Tactical Sensors, Advanced Sensing Technologies, Optical Tags and Wolfpack.

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(U) The Situational Awareness System (SAS) will integrate a variety of communications, navigation and data processing technologies into an eventual 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The Agency module will be interoperable with the Army Land Warrior equipment and provide much greater functionality. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. This program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested and mountainous terrain. It will also acquire and codify knowledge of dispersed land force tactics to develop decision aids and evaluate the utility of the aids for small units. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the SAS functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises to provide independent validation of the SAS functionality.

(U) The Tactical Sensors program will develop new sensor system technologies that will provide the warfighter with a capability to detect, track and classify mobile tactical targets, and to characterize fixed, man-made structures. These sensor systems provide a local, in-situ sensing capability near high value targets or at choke points in denied areas. Information provided by these sensors can be fused with other longer-range space, airborne and ground sensor systems to enhance the aggregate surveillance and tracking capabilities of US forces. Applications include surveillance, cueing, precision targeting, intelligence and battle damage assessment with respect to time critical, mobile targets (vehicles and humans) and to fixed man-made structures (surface and underground facilities).

(U) The Optical Tags Program will investigate optical technologies and innovative design and fabrication techniques for kilometer-range optical tag systems, which provide a quantum leap in tactics and operations in a wide variety of applications. The Optical Tags Program will develop validated models to predict system performance in support of a selected set of applications for technology demonstration. The program will select a relatively mature application, such as marking or tagging, and a relatively immature application, such as precision strike. The applications will be selected based on their operational significance and user input. The Optical Tags Program will perform system engineering to develop systems performance requirements for the applications and will demonstrate the systems in meaningful warfighter experiments.

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(U) The Wolfpack Program will develop technologies that would enable the U.S. to deny the enemy use of radio communications throughout the battlespace. This will culminate in a networked system of air emplaced, autonomous, ground-based monitors/jammers linked together to cooperate and avoid disruption of friendly military and protected commercial radio communications. The specific technologies to be developed include: (1) high efficiency sub-resonant antennas, (2) networking algorithms to allow coordinated access to the spectrum by communicators, jammers and SIGINT systems, (3) methods to easily deploy the systems high terrain high points, and (4) algorithms to rapidly and autonomously detect, classify, identify and jam target signals with low power electronics.

(U) The Advanced Sensing Technologies program will develop a completely new class of sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, classification, cueing and bomb damage assessments at distances much greater than current capabilities. The sensors will use recent technical breakthroughs to permit vulnerability and access to the target signatures. Program completion is anticipated in FY 2001.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Situational Awareness System. ($ 30.618 Million) [Future Combat Systems – related = $17.900 Million]
  - Completed development of the Individual Warfighter Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile and Relay/Router/Beacon detailed hardware design, software modules and network protocols.
  - Completed Individual Warfighter/WTA software coding.
  - Completed IWSAS, WTA-Base, WTA-Mobile, Relays and network code development and testing.
  - Completed situation awareness (planning, tasking, sensor control, navigation and alerts) application software coding and testing.
  - Completed brassboard fabrication of the major SAS elements (IWSAS, WTA and Relays).
  - Conducted performance assessment of Phase 3 brassboard design.
  - Verified that Individual Warfighting Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
  - Verified geolocation accuracy and navigation performance in urban and field environments.
  - Developed Wolfpack system architecture and conduct system level trades to develop sub-system requirements.

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- Determined the optimum use of legacy systems for IPB and cueing, and potential modifications required for coordinated spectrum access.

• Tactical Sensors. ($ 8.629 Million)
- Continued development of internetted remote control sensors to detect, localize and characterize targets.
- Continued development of surveillance and targeting sensors systems for dispersed operations.
- Developed mature application performance requirements for optical tags.
- Developed optical tag performance prediction modeling capability.

• Advanced Sensing Technologies. ($ 2.839 Million)
- Completed and tested breadboard sensor.
- Initiated brassboard development.

(U) **FY 2001 Plans:**

• Situational Awareness System. ($ 13.344 Million)
- Complete fabrication of Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) Mobile and Base, tactical sensors and tactical relays for test.
- Integrate IWSAS, WTA-Mobile and Base with external legacy communications, data and sensor equipment.
- Test integrated system and conduct performance assessment of final Phase 3 design; measure IWSAS, WTA and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
- Complete development of detailed demonstration scenarios to test and evaluate performance under operational conditions.

• Tactical Sensors. ($ 7.944 Million)
- Continue development of internetted remote control sensors to detect, localize and characterize targets.
- Continue development of surveillance and targeting sensors sytems for dispersed operations.

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- Optical Tags. ($ 4.944 Million)
  - Fabricate appliqué-based optical tag with appropriate spectral response and demonstrate that it achieves desired performance over kilometer-class range.
  - Develop performance model in the mature (e.g. ground-to-ground) application, for both appliqué and random matrix tags, and predict performance over a wide range of scenarios.

- Advanced Sensing Technologies. ($ 2.944 Million)
  - Complete brassboard and initiate fieldable sensor development.

- Wolfpack. ($ 5.944 Million)
  - Complete system design and performance analysis.
  - Conduct proof-of-concept demonstrations of high-speed signal detection and identification algorithms.
  - Verify low duty cycle, low power jamming techniques with benchtop experiments.
  - Conduct analysis for the applicability of distributed ground jammers to attack surface to air radar systems.

(U) **<u>FY 2002 Plans:</u>**

- Situational Awareness System. ($ 9.919 Million)
  - Perform setup of field demonstration.
  - Develop training materials and conduct soldier training for field demonstration.
  - Conduct field demonstration to verify communications performance in urban, forested and mountaneous terrain when operated by warfighters. Show the use of multiple organic sensors being operated by battalion and below warfighters.

- Optical Tags. ($ 11.919 Million)
  - Verify basic tag prototype design in lab setting tests.
  - Conduct engineering tests of improved tags for more stressing situations.

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- Tactical Sensors. ($ 3.918 Million)
  - Complete development and field-test internetted remote control sensors to detect, localize and characterize targets.
  - Complete development and field-test surveillance and targeting sensors systems for dispersed operations.

- Wolfpack. ($ 11.919 Million)
  - Initiate construction of brassboard jamming system.
  - Conduct field tests using brassboard equipment to attack several legacy type communication systems.

(U) **FY 2003 Plans:**

- Optical Tags. ($ 16.824 Million)
  - Field demonstration of covert tags application to verify overall system performance.
  - Complete design of improved tag and test in lab setting.

- Wolfpack. ($ 20.776 Million)
  - Complete enabling technology development.
  - Complete prototype jamming systems.
  - Conduct distributed jamming experiments.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

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(U) **Schedule Profile:**

Plan	Milestones
Situational Awareness System:	
Jun 00	Complete SAS sensor and weapon simulation.
Feb 01	Complete brassboard SAS integration and test.
Jun 01	Complete SAS software coding.
Oct 01	SAS engineer development model fabricated.
Jun 02	SAS final demonstration
Tactical Sensors:	
Aug 00	Demonstrate brassboard integrated micro-(UGS) system.
Sep 01	Complete micro-UGS field demonstration tests.
Sep 02	Complete systems integration and final field tests.
Optical Tags:	
Mar 01	Basic tag performance predicted.
Jun 01	Improved response tag requirements developed and performance predicted.
Jan 02	Design and test basic tag prototype.
Jul 02	Test improved response tag prototype.
Sep 03	Basic tag system field test.
Advanced Sensing Technologies:	
Sep 00	Demonstrate final breadboard.
Sep 01	Demonstrate final brassboard.
Wolfpack:	
Mar 01	Initial enabling technology demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02

Jun 01	Single sensor performance verified in laboratory.
Dec 01	Brassboard system completion.
Jun 02	Brassboard field-testing completion.
Aug 03	Prototype jammer demonstrated.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Future Combat Systems LNW-03	0.000	61.000	90.000	122.000	62.000	15.000	15.000	15.000	Continuing	Continuing

(U) **Mission Description:**

(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat System (FCS) program was developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities.

(U) The FCS program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of an ensemble of manned and unmanned ground and air platforms. The goal of the FCS project is to design such an ensemble that strikes an optimum balance between critical performance factors, including ground platform strategic, operational and tactical mobility; lethality; survivability; and sustainability. This system of systems design will be accomplished by using modeling and simulation and experimentation to evaluate competitive concepts. The success of these efforts enables consideration of a modern, light force that does not rely solely on a heavy armor based force structure.

(U) A Government Run Experiments effort will provide the Future Combat Systems (FCS) program a link between the dedicated FCS Concept Development Effort and the DARPA programs providing key technology exploration/development in support of the FCS Concept Development Effort. The effort will comprise a series of experiments, both real and simulated, to validate emerging technological and operational conclusions.

(U) DARPA studies have identified six keys areas where technology development is needed to support the overall FCS system of systems design: robotics, unmanned ground vehicles, maneuver command control and communication (C^3), beyond line of sight fires, organic all weather air vehicles and organic all weather targeting.

(U) The Robotics program will identify and investigate revolutionary unmanned vehicle control architectures and enabling technologies that provide capabilities for unmanned and/or combined unmanned/human-assisted ground platforms for maneuver, control, tactical integration, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

mission execution. These investigations will consider varying levels of autonomy and telepresence, will balance the use of on-board and off-board sensors, and will assess the use of terrain data and route planners.

(U) The Unmanned Ground Vehicle program will develop physical solutions to provide much-improved ground mobility of unmanned vehicles. These may include unique mobility configurations (traditional wheeled/tracked to organic-mimicking, i.e. walking/crawling), exceptional drivetrains, advanced structures/composites, terrain/soil analysis, sensory exploitation and interaction with robotic control architectures.

(U) The Maneuver C^3 program will investigate the core Future Combat System (FCS) network centric requirements, including multi-platform (small-unit) combined C4ISR as well as higher level information creation, dissemination, classification, distribution and control. The network centric initial investigations will include the decomposition of the FCS C^3 requirements and prioritization to determine a network structure. Variable levels of human-in-the-loop and autonomous (i.e. "associate") operation will be investigated. Software/hardware requirements and possibilities will be researched, designed, and implemented to test appropriate control architectures, structures, bandwidth requirements, and robustness. The capability to provide rapid unit responses (within seconds) is highly desired. Advanced communications will be developed to assure connectivity. The C^3 effort will incorporate robust use of Electronic Warfare (EW) and counter-EW to protect data and system integrity.

(U) The Netfires (formerly Advanced Fire Support System) program will develop and test a containerized, platform-independent multi-mission weapon concept as an enabling technology element for FCS. NetFires will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, and lower life-cycle costs, while increasing survivability compared to current direct fire gun and missile artillery. NetFires will allow FCS to defeat all known threats, will be air deployable in C-130 (and smaller) aircraft, and will enhance the situation awareness and survivability of FCS by providing standoff target acquisition and extended-range, non-line-of-sight engagements. The program will develop and demonstrate a highly flexible modular, multimission precision missile and a loitering attack missile that can be remotely commanded. Both missile types will have a self-locating launcher and a command and control system compatible with FCS.

(U) The Organic All-Weather Targeting Vehicle program provides FCS direct and indirect weapons system targeting under all operating conditions at the small unit level. Particular emphasis will be placed upon determining the trade-offs between platform types, resulting in an optimized multi-tiered architecture.

(U) The All-Weather Surveillance and Targeting Sensor program will develop and test advanced sensor concepts for the Future Combat System. The effort will exploit a variety of sensors aboard mobile manned/unmanned ground and air based platforms. The distributed aperture triad

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

(for ground combat vehicles and small unit UAVs) of ground moving target indication/synthetic aperture radar (GMTI/SAR), emitter detection/mapping SIGINT, and narrow field of view active/passive coherent/incoherent electro-optical based systems will be explored and developed from a unit level perspective.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

(U) This program was funded in FY 2000 from Project LNW-01, Rapid Strike Force Technology, within this same Program Element.

(U) **FY 2001 Plans:**

- FCS Concept Development. ($ 15.000 Million)
  - Perform multiple iterations of concept design.
  - Receive data for concept evaluation.
  - Perform technical/operational oversight of concepts.
  - Prepare analysis evaluation tools.
- Robotics. ($ 6.000 Million)
  - Develop initial unmanned maneuver architecture possibilities including the use of varying levels of autonomy and telepresence or operation, tradeoffs between complete organic sensory capabilities versus off-board or hybrid methods, reliance on embedded information/analysis (i.e. terrain data and route planners) versus passive methods (i.e. complete sensory for encounter), and inter-relations between robotic architecture presence/control/action possibilities and physical capabilities.
  - Research/identify enabling technologies (sensory or otherwise) for architectures.
- Unmanned Ground Vehicle (UGV). ($ 5.000 Million)
  - Complete Phase I study of UGV design drivers. Highlight critical technologies for achieving higher mobility and endurance in configurations associated with both combat and support duty vehicles in the context of the FCS mission.
  - Initiate Phase II work on UGV technology testbeds with traceability to fieldable UGV concepts.

<table>
<tr><td colspan="2">RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</td><td>DATE
May 2000</td></tr>
<tr><td>APPROPRIATION/BUDGET ACTIVITY
RDT&E, Defense-wide
BA3 Advanced Technology Development</td><td colspan="2">R-1 ITEM NOMENCLATURE
Land Warfare Technology
PE 0603764E, Project LNW-03</td></tr>
</table>

- Conduct low-cost surrogate UGV field-testing.

• Maneuver C^3. ($ 10.000 Million)
- Develop network centric functional decomposition for Future Combat Systems (FCS).
- Assign hierarchical network centric levels for information collection, storage, dissemination, interpretation and control.
- Provide initial architecture options to address functions and levels.
- Develop technologies for assured communication in a hostile environment.

• Netfires. ($ 10.000 Million)
- Continue system hardware and software development for missiles, container/launchers and command/control units.
- Complete critical component demonstrations for motor, seeker, navigation and data link.
- Plan and initiate preparations for flight test demonstrations.

• Organic All-Weather Targeting Vehicle. ($ 10.000 Million)
- Determine requirements for organic air vehicle to be used as sensor platforms.
- Develop air vehicles capable of operating in adverse weather.

• All-Weather Surveillance and Targeting Sensor. ($ 5.000 Million)
- Initiate concept development.
- Initiate sensor development for GMTI/SAR, SIGINT and NFOV technologies.

(U) **<u>FY 2002 Plans:</u>**

• FCS Concept Development. ($ 30.000 Million)
- Evaluate team concepts via modeling, simulation and specialized analysis.
- Prepare Phase II program plans.
- Perform concept downselect to two options.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

- Transition from concept development effort to preliminary design.
- Prepare and apply technology readiness levels (TRLs).

• Robotics. ($ 10.000 Million)
- Select architecture(s) and subsequent enabling technology for detailed design and implementation.
- Initiate design.

• Unmanned Ground Vehicle (UGV). ($ 4.000 Million)
- Continue work on Phase II technology testbeds and complete initial testing.
- Update operational concepts based on testbed fabrication and testing results.
- Plan and initiate preparations for integrated UGV testbeds use in operational exercises.
- Conduct field-testing with upgraded surrogate.

• Maneuver C^3. ($ 14.800 Million)
- Select network centric architecture(s) for detailed investigation.
- Initiate development and supporting hardware/software research/development efforts.
- Demonstrate technologies for assured communication in a hostile environment.

• Netfires. ($ 16.200 Million)
- Initiate ballistic test vehicle and controlled test vehicle demonstrations.
- Complete pintle motor development and testing.

• Organic All-Weather Targeting Vehicle. ($ 10.000 Million)
- Select platform and sensory payload for detailed design and prototyping efforts.
- Initiate detailed design efforts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

- All-Weather Surveillance and Targeting Sensor. ($ 5.000 Million)
  - Continue sensor development and initiate breadboard sensor demonstrations.

(U) **FY 2003 Plans:**

- FCS Concept Development. ($ 48.000 Million)
  - Transition from preliminary design to detailed design/prototype development.
  - Provide technical roadmaps for Army technology decision determining FCS development within timeframe.

- Robotics. ($ 12.000 Million)
  - Continue architecture and supporting technology developments for unmanned maneuver.
  - Perform testing.

- Unmanned Ground Vehicle. ($ 6.000 Million)
  - Complete technology testbed experiments and update any late design changes into integrated UGV hardware/software.
  - Complete fabrication of integrated UGV testbeds for use in field-testing with other Future Combat Systems (FCS) hardware.

- Maneuver C^3. ($ 25.300 Million)
  - Continue network centric architecture development and sub-scale performance validation.
  - Continue development of data communication and storage structure.

- Netfires. ($ 10.700 Million)
  - Complete controlled test vehicle demonstrations and initiate guided test vehicle demonstrations.
  - Conduct critical design reviews.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

- Organic All-Weather Targeting Vehicle. ($ 12.000 Million)
  - Continue prototype platform development and sensory payload.
  - Perform testing.

- All-Weather Surveillance and Targeting Sensor. ($ 8.000 Million)
  - Finalize sensor development and conduct sensor demonstrations in quasi-tactical environments against notional FCS threats.
  - Conduct critical design reviews.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 2000	FY 2001	FY 2002	FY 2003
PE 0602601A Combat Vehicle and Automotive Technology	0.000	7.752	19.564	0.000
PE 0603005A Combat Vehicle and Automotive Advanced Technology	0.000	5.312	61.586	146.500

(U) **Schedule Profile:**

Plan	Milestones
Oct 00	Kick-off Phase I UGV design studies and critical technology demonstration phase.
Oct 00	NetFires critical design review.
Feb 01	Sensor development awards.
Apr 01	NetFires critical component tests.
May 01	Complete Phase I Unmanned Ground Vehicle (UGV) designs and select candidates for Phase II.
May 01	FCS risk reduction independent design review (IDR).
Aug 01	End of concept development by contractors.
Sep 01	Complete UGV early surrogate tests of high-risk/long-lead technologies.
Feb 02	Complete UGV technology testbed data collection.
Mar 02	FCS Downselect (end of Phase I efforts).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03

Apr 02	NetFires ballistic test vehicle firings.
April 02	Sensor breadboard testing (laboratory).
May 02	Complete UGV integrated testbed detailed design and procure long lead items for fabrication.
Sep 02	Roll-out UGV first integrated testbed baseline configuration.
Mar 03	Army decision on FCS technology readiness levels.
May 03	Complete UGV fabrication of all integrated testbed vehicles and prepare for field testing.
July 03	Sensor field tests.
Sep 03	Complete UGV contractor testing of all integrated testbeds for prepare for government testing in complete FCS environment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE May 2000	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support					R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	32.132	34.679	38.954	40.314	42.402	42.502	42.542	42.542	Continuing	Continuing
Management Headquarters (R&D) MH-01	32.132	34.679	38.954	40.314	42.402	42.502	42.542	42.542	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the military services for administrative support costs associated with contracts undertaken on the agency's behalf.

(U) **Program Accomplishments and Plans:**

(U) **FY 2000 Accomplishments:**

- Management Headquarters. ($ 32.132 Million)
  - DARPA continued to fund civilian direct-hires and administrative support service costs. Salary reimbursement for IPAs was funded with program funds in keeping with OMB policy. Reductions associated with this change were substantially offset by the additional costs of the Section 1101 experimental hiring program.

(U) **FY 2001 Plans:**

- Management Headquarters. ($ 34.679 Million)
  - DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Expanded Departmental and Federal physical and information security requirements and anticipated pay raise requirements are also funded.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, R-1 #121

(U) **FY 2002 Plans:**

- Management Headquarters. ($ 38.954 Million)
  - DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Anticipated pay raise requirements are also funded. Finally, the costs associated with statutory financial statement audits are also included.

(U) **FY 2003 Plans:**

- Management Headquarters. ($ 40.314 Million)
  - DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Audit costs and anticipated pay raise requirements are also funded.

(U) **Program Change Summary:** (*In Millions*)	**FY2000**	**FY 2001**	**FY 2002**	**FY 2003**
Previous President's Budget	32.103	34.679	35.954	37.276
Current Budget	32.132	34.679	38.954	40.314

(U) **Change Summary Explanation:**

FY 2000	Increase reflects mandated pay raise requirements.
FY 2002 - 03	Increase reflects anticipated pay raises and additional audit and accounting system requirements.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE May 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA66 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

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POM 2002 – 2007

Supplemental

Exhibits

Format E-10: Environmental Security Technology

(Current $ Millions)

Defense Advanced Research Projects Agency

Active Component	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007
Pollution Prevention									
0602712E - Materials and Electronics Technology									
Project: MPT-01 Materials Processing Technology									
RDT&E									
6.2 Exploratory Development	2.494	0.345	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total (MPT-01 Materials Processing Technology)	2.494	0.345	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total (0602712E)	2.494	0.345	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total (Pollution Prevention)	2.494	0.345	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Grand Total	2.494	0.345	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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Format G-1: ITR/DII Resources / Functional AIS (Detail)

Defense Advanced Research Projects Agency

C&CI Initiative Or Functional Name: ALL OTHER (FAA) SCIENCE AND TECHNOLOGY Initiative # Or AIS #: 5019
IT/DII Resource Area: Functional Area Applications
C&CI/RTA Function Or Specific Functional Area: SCIENCE AND TECHNOLOGY C&CI/RTA Program Area Or Functional Activity: SCIENCE AND TECHNOLOGY
Migration Status Category: Standard or Migration Systems IT Strategic Plan Goal/Obj #: 2 System Categorization: All Other
Special Interest Item: None JTA: Compliant as designed or currently operating COE Compliance: B

Current $ in Millions/End Strength in (000s)

Resource Baseline	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007
Development and Modernization									
Funding Source/Appropriation									
R, D, T and E-Defensewide	7.462	10.608	9.035	9.035	9.035	9.035	9.035	9.035	9.035
Total	7.462	10.608	9.035	9.035	9.035	9.035	9.035	9.035	9.035
Current Services									
Funding Source/Appropriation									
R, D, T and E-Defensewide	4.018	5.712	4.865	4.865	4.865	4.865	4.865	4.865	4.865
Total	4.018	5.712	4.865	4.865	4.865	4.865	4.865	4.865	4.865
Total Resources (Dollars)	11.480	16.320	13.900	13.900	13.900	13.900	13.900	13.900	13.900

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(U) Format I-1 Unified Commands
POM Support of USSOCOM

Overview: DARPA's mission is to conduct high risk/high payoff research and development programs that enable radical advances in Service warfighting capabilities and prevent technological surprise by U.S. adversaries. DARPA has a long history of accomplishment in support of the Services and Unified Commands ranging from radar advances (Joint STAR), navigation improvements (Global Positioning System applications), radar-evading technology development (stealth), simulation (synthetic theater of war) and communications.

The Agency continues to support the Services and Unified Commands through its investment in technologies to enable "operational dominance" for future warfighting. DARPA programs in this area directly target Service needs and include technologies and systems to enable affordable, precision, moving target kill, dynamic command and control capabilities for commanders, and future warfare concepts for air, space, land and sea. Major operational dominance programs include the Future Combat System, Unmanned Combat Air Vehicles, and Discoverer II. DARPA is also working with the Services and Unified Commands to use experimentation as a vehicle to provide the iteration between operational concept and technology development. Recent experimentation activities include a partnership with the Air Force focusing on innovative ways to locate and destroy mobile targets, and work with the US Joint Forces Command using DARPA Synthetic Theater of War (STOW) ACTD to examine joint attack operations in 2015.

A. **CINC Priority Item**: Tech Base Funding

CINC Statement of Programmatic Concern: MFP-11 is neither structured nor resourced to support high-risk, high-dollar, long-term, but high-value added technology developments. It is imperative that service and agency programs support exploratory and advanced technology development with Special Operations Forces (SOF) applications in the areas of personnel survivability, counter WMD, mobility in denied areas, recruitment and leader development, information avenues, sensory enhancements, organization design, remote reconnaissance, and versatile weapons.

B. **Funding Profiles**. The following DARPA programs are currently coordinated with or are expected to support USSOCOM operations: ($, Millions)

DARPA Program	SOF Priority Areas	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
Active Templates	Information Avenues	7.5	10.0	8.9	7.0		
Tactical Mobile Robotics	Mobility in Denied Areas	15.2	12.2	3.4	2.0	2.0	2.0
Metal Storm	Versatile Weapons		10.8	5.9			
Optical Tags	Sensory Enhancements	1.9	4.9	11.9	16.8		
RST-V	Mobility in Denied Areas	10.7	8.8	3.0			
Advanced Air Vehicles (A160)	Versatile Weapons	5.2	1.5	5.0	7.0		
Personnel Protection	Personnel Survivability	3.9	4.0	6.0			
Classified (JSDP)		2.8	7.9	12.8	10.0		
TOTALS		**47.2**	**60.1**	**56.9**	**42.8**	**2.0**	**2.0**

C. **Narrative Descriptions of Efforts:**

1. **Active Templates** - The Active Templates (AcT) program will produce a robust software technology for aiding in the automation of detailed planning and execution for military operations using a "plan spreadsheet" metaphor. The program will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, scalable, and widely adopted. As a result, the technology to be fielded will provide faster plan generation (6 times), improved plan quality (8 times more options considered), 60 percent reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis. The Joint Special Operations Command (JSOC) has been selected to identify stressing military command and control problems and to help develop user experiments and test new operational concepts. JSOC constitutes a valuable testbed with unique ability to help transition Active Template technology to various sectors of the military including US Special Operations Command, the special operations forces attached to each theater commander, and light infantry forces of the US Army and US Marine Corps.

2. **Tactical Mobile Robotics** - The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with semi-intelligent, cooperating platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: perception, autonomous operation and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction and (b) traversal of rugged/complex terrain using 1 command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to 1 m/s over 25 cm steps and decimeter-scale rubble. USSOCOM is participating with SOF employment concept development.

3. **Metal Storm** - The Metal Storm (MS) program will develop a unique 100 percent solid state system for tightly packing, storing, transporting and firing projectiles in multiple tubes with high or low pressures, in an electronically infinitely variable sequence rate with applications to small arms and crew served weapons. The program facilitates current US force reduction and restructuring policies while increasing firepower. The program will demonstrate revolutions in weapon designs and applications that will far exceed the effectiveness and versatility of existing small arms and large munitions weaponry and will primarily focus on developing, fabricating and testing two 7.62 mm sniper rifle prototypes for Special Operations Forces use.

4. **Optical Tags** - The Optical Tags Program will develop and bring to maturity upconverting phosphor technology for use in covert optical tags. The technical approach will investigate innovative design and fabrication techniques for kilometer-range systems, which provide a quantum leap in tactics and operations in a wide variety of applications, both military and civilian, such as downed pilot extraction, covert urban tracking, small unit operations, precision targeting, and alternatives to land mines. These will be demonstrated in meaningful warfighter experiments, including participation by USSOCOM.

5. <u>RST-V</u> - The Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate and transition to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension, including both active and passive approaches. The vehicle will also host integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting (RST) sensor subsystems. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators and special reconnaissance forces. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ATD as well as address joint US Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV) and Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. SOF operational personnel from 5th Group, Ft. Campbell are actively participating in meetings and reviews for this program.

6. <u>Advanced Air Vehicles</u> The Advanced Air Vehicles (AAV) Program will explore promising new concepts for both manned and unmanned air vehicles. Innovative design concepts which provide significant advances in vehicle performance, affordability and military utility will be developed and validated through simulation, component testing and in-flight demonstrations. The A160 task of the AAV program will design, fabricate and establish the reliability and maintainability of the A160 helicopter utilizing low disc loading, variable RPM, high L/D configuration, and a hingeless (rigid) rotor. This unique concept offers the potential for significant increases in VTOL UAV range (2,000-3,000 nm) and endurance (24-48 hours). The A160 rotor concept will achieve an efficient low power loiter to achieve its endurance goals and low acoustic signature. The A160 program will culminate in a series of flight demonstrations that will validate the performance and reliability of the basic air vehicle concept. During these tests, interface with the CINCs and the military services will be maintained to assess the military utility and applicability of the concept to particular mission needs. Following these demonstrations and user evaluations a joint DARPA/DOD plan for the continued development and deployment of the concept will be defined.
SOF is contributing $1.570 million from FY 2000 to FY 2002 towards the effort.

7. <u>Personnel Protection</u> – The Personnel Protection program is developing new materials systems concepts to significantly lower the areal density of body armor systems. The target areal density is 3.5 lbs/ft2 against 7.62 mm (30 cal) armor piercing (AP) rounds, compared to current systems that weigh 6.5 lbs/ft2 or more. The current weight of body armor limits the mobility and effectiveness of soldiers, assuming they decide to take the weight penalty and wear it. Dramatically reducing the weight of the armor system will increase usage while allowing complete operational mobility and effectiveness. This will save lives while enhancing mission performance. This effort has changed the paradigm for developing body armor, moving from the current approach of "shoot and look" to that of understanding the behavior of armor systems through modeling and testing, thereby exploiting new materials and defeat mechanisms. As the agent for this program, the U.S. Army Soldier System Command will ensure full integration with other Army programs and SOF requirements.

8. <u>JSDP</u> - JSDP is a classified program that supports some SOF missions.

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Format N-5A: Competition and Strategic Sourcing - A-76 Studies

(Current $ Millions, Military End Strength, Civilian Full Time Equivalents)

Defense Advanced Research Projects Agency

	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007
Single Function Studies									
Total Positions Studied/to be Studied									
Manpower									
Civilian Full Time Equivalents (FTEs)									
RDT&E	0	0	0	0	0	0	0	0	0
Total Civilian Full Time Equivalents (FTEs)	0	0	0	0	0	0	0	0	0
Total Civilians and Military	0	0	0	0	0	0	0	0	0

Format N-5A: Competition and Strategic Sourcing - A-76 Studies

Defense Advanced Research Projects Agency

COMMENTS:

There are neither civilian nor military positions at the Defense Advanced Research Projects Agency (DARPA) which are subject to competition or direct conversion under the A-76 process.

DARPA program manager positions comprised of 50 civilians, 50 IPAs (non direct hires) and 18 military billets are directly engaged in the RDT&E function and are deemed to be inherently governmental. The 50 civilian positions, including 20 positions authorized under Section 1101 Experimental Personnel Management Authority in the FY 1999 Authorization Act, exercise civilian manpower authority (including direction and final decision making) over governmen policies, programs, property, and information. The 50 IPAs make decisions on behalf of the government and are directly and ultimately accountable for the accomplishment of assigned functions. The 18 military positions require military unique knowledge and skills primarily in the determination of weapon system operations management and to ensure that research efforts are directed toward proper military requirements and application. The IPA and military billets are no included in the 141 direct hire workyears reported in the POM exhibits.

Seventy-one civilian positions are categorized as providing direct management support, which requires civilian expertise to ensure oversight, control, and accountability over governmental operations and federally funded projects. These positions provide corporate knowledge and technical expertise necessary to ensure that government interests are advanced and that government contracted obligations are fully satisfied.

The remaining 20 twenty positions are involved in direct administrative support to the RDT&E function and have been exempted from competitive sourcing studies under A-76 by the Director of DARPA under authority vested in him as a Director of a Defense Agency (or DoD Field Activity) as described in the Inherently Governmental and Commercial Activities Inventory Procedures promulgated by the Office of the Secretary of Defense in April 1998.

Format O-11: DARPA Biological Warfare Defense Program (Dedicated Support)

(TOA Current $ Millions, Military End Strength, Civilian Workyears)

Defense Advanced Research Projects Agency - Active

DARPA Biological Warfare Defense Program Dedicated Resources

Program: Biological Warfare Defense

Point of Contact : Ann Morgan

Commercial Phone Number: (703) 696-2413

DSN Phone Number: 426-2413

Facsimile Number: (703) 696-2200

Description:

Funding reported on this exhibit is consistent with data previously provided for the Department's Combating Terrorism justification book and the OMB Weapons of Mass Destruction exhibit (as updated with POM budget changes). The DARPA BWD program is a supporting element of the DoD's Combating Terrorism Program and addresses technologies to thwart the use of biological warfare agents by both military and terrorist opponents. DARPA is the principal DoD research organization funding the development of broad responses to both the biological warfare threats identified on the current threat list, and those that could be introduced in the future. The funding reported here is not specific to dedicated domestic support due to the nature of the research funded, and outcomes are expected to benefit both the military and the domestic preparedness program.

Estimated POM Resources (Current Capability)

	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007
TOA									
Defense Advanced Research Projects Agency									
0602383E									
RDT&E	84.009	125.466	162.064	140.180	149.000	169.000	173.000	173.000	173.000
Total TOA	84.009	125.466	162.064	140.180	149.000	169.000	173.000	173.000	173.000

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Format R-1: Military Transformation Activities

(Current $ Millions)

Defense Advanced Research Projects Agency

RDT&E

	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007
Science and Technology									
Basic Research	57.369	66.033	90.415	105.263	109.398	114.259	116.118	121.118	126.118
Applied Research	900.891	917.206	1025.562	1005.588	1005.763	1041.461	1091.477	1112.177	1132.177
Advanced Technology Development	848.991	785.254	795.649	805.295	841.925	815.178	790.103	806.103	823.503
ACTDs	58.989	20.867	9.925	9.893	0.000	0.000	0.000	0.000	0.000
ATDs	77.434	56.137	22.736	23.327	24.400	0.000	0.000	0.000	0.000
Total, Science and Technology (Less ACTDs and ATDs)	1807.251	1768.493	1911.626	1916.146	1957.086	1970.898	1997.698	2039.398	2081.798
Total, Military Transformation (Less ACTDs and ATDs)	1807.251	1768.493	1911.626	1916.146	1957.086	1970.898	1997.698	2039.398	2081.798

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